Constructivist Approaches to Teaching and Learning

Handbook for Teachers of Secondary Stage

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Editor
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राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

stage in improving the teaching-learning process and achieving the objectives of the curriculum.

I express my sincere thanks to the authors, contributors of subject specific illustrations and participants of the review workshop.

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December 2005

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CONSTITUTION OF INDIA

Preamble

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a **SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC** and to secure to all its citizen:

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

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CONSTITUTION OF INDIA

Part IV A (Article 51 A)

Fundamental Duties

Fundamental Duties – It shall be the duty of every citizen of India —

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wildlife and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;

(k) who is a parent or guardian, to provide opportunities for education to his child or, as the case may be, ward between the age of six and fourteen years.

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Constructivism

1.1 Rationale

The traditional methods of teaching are based on *objectivist* view of knowledge. In objectivist paradigm, the teacher *transmits* knowledge to the learners who are considered as passive receivers of knowledge. It is believed that the teacher has all the knowledge and the teacher is the source of 'right' knowledge and 'correct answers'. In contrast, the constructivist paradigm is based on the assumption that knowledge is subjective and learners construct knowledge in the social and cultural environment in which they are embedded.

Piaget, Vygotsky and Novak have suggested different theories of constructivism. Piaget suggests that children construct knowledge individually whereas according to Vygotsky, social interaction is important for the construction of knowledge. Driver, Novak and Posner believe that classroom interaction facilitates knowledge construction.

In a constructivist classroom, the teacher assumes the role of a facilitator and guide. Teacher becomes the manager and not the controller of the class. Students take the responsibility of their own learning. They question, state problems, design experiments and discuss their results with others. Students construct knowledge and do not receive knowledge as passive learners.

1.1.1 Objectives

After reading this chapter, you will be able to:

- understand the concept of 'constructivism';
- distinguish between 'traditional' approach to teaching and 'constructivist' approach to teaching;

- suggest teaching methods in a constructivist classroom;
- suggest management and organisational strategies in a constructivist classroom; and
- create constructivist culture in the classroom.

1.2 Introduction

Most of the time, teachers teach by the lecture method and sometimes take up activities to verify the factual knowledge given in the textbooks. These methods of teaching are used since teachers believe that their role is to transmit authoritarian knowledge to the passive learners.

These traditional methods of teaching and learning are based on *objectivist* view of knowledge. Objectivism is based on the assumption that knowledge is objective, universal and complete and it can be imparted by those who have it, to those who do not have it. Constructivism on the other hand is based on the assumption that knowledge is subjective, contextual and inherently partial. Objectivism thus presents knowledge as authoritarian and certain, whereas constructivism focuses on the resilience of the learner's beliefs and the social construction of reality.

In objectivist paradigm, teacher transmits authoritative knowledge to passive students whereas in constructivist paradigm students construct knowledge in the particular context in which the cognizing individual is operating (Von Glaserfeld 1989).

Constructivism as general philosophy has a long history (Hawkins, 1994) and major theorists such as Dewey, Montessori, Piaget and Vygotsky are constructivists at root. These theories, however, failed to support significant reforms in education because these could not translate constructivist perspectives into educational practice.

In 1978, Driver and Easley published an article which states that interventions provided in the classroom can help children to construct their own concepts. They believed that learners construct knowledge on the basis of their prior knowledge and personal experience. Driver and Easley's article is taken as the beginning of the *Constructivist Movement* for improvement of teaching-learning processes.

Thereafter a number of studies were conducted by Posner (1982), Driver (1989), Novak (1993) and others on 'how children construct knowledge' and 'how teacher can provide interventions

to help children construct their own concepts'. The empirical data from these studies shows that when individuals encounter new information, they use their own prior knowledge and personal experience to make sense of the new material. During the meaning-making process, individuals reformulate the new information, restructure their existing knowledge and reorganise their prior conceptual schemes. These researches also indicate that the construction of knowledge can be facilitated by intervention in the class.

A number of educators have been investigating instructional strategies which are effective in facilitating student's conceptual changes (Posner, Strike, Hewson & Gertzog, Novak, Driver). The new constructivist paradigm provides teachers with an alternative way of viewing their teaching.

1.3 Constructivist View Of Learning

Although constructivists like Piaget, Vygotsky, Novak and Posner disagree on some aspects of the knowledge construction process, they all agree on the basic characteristics of constructivism such as:

- Learning is not a passive receptive process but is instead an active meaning-making process required to solve meaningful problems.
- New learning depends on learner's previous knowledge, which may sometimes interfere with the understanding of new information.
- Learning implies the reorganisation of prior conceptual schemes.
- Learning is facilitated by social interaction.
- Meaningful learning occurs within authentic learning tasks.

Piaget believed that learning is strongly influenced by the learner's developmental stages. Learners move through identifiable stages of physical, intellectual, emotional and social growth that determine what can be learned and with what depth of understanding. Learners learn best when they are at their proximal stage of development. Learning involves metacognition, which reflects on one's learning process. The nature of the learning task is crucial for learning to take place. The learning tasks of optimal difficulty, authenticity and relevancy enhance learning. Challenging and novel tasks help students to stretch their efforts.

Vygotsky believed that learning is social in nature. Learning involves interaction between the learner and teacher, and also amongst learners. During this interactive process, meanings are shared and information is exchanged. The class then becomes a social arena for increasing one's knowledge. By comparing their understanding with that of others and by examining their knowledge against other's knowledge, students develop new understandings. Social interaction in a constructivist lesson is important because it encourages students to think about their ideas, as well as compare their ideas with those of others. For example, while solving problems cooperatively, the learners interact with others; they contribute to their knowledge from what they know and from what others know. They debate, reason, infer and conclude in the process of solving the problem. Social interaction in the constructivist approach encourages students to verbalise their thinking and refine their understandings by comparing them with those of others.

Contemporary constructivists like Driver, Posner, Novak and Osborne assume that learning is an adaptive process in which learners' conceptual schemes are progressively reconstructed so that they are in keeping with a continually wider range of experiences and ideas. It is also seen as an active process of sense-making over which the learner has some control. Posner (1982) formulated the theory of conceptual change and indicated the conditions required for it to occur. For conceptual change, the students must feel dissatisfied with their own conceptions which are not sufficiently explicative. The new knowledge should be intelligible, plausible and fruitful. Many researchers have considered conceptual change as a model of learning. In this model, learning implies conceptual change. This conceptual change might extend, evolve or recognise prior knowledge or it might substitute or change prior knowledge for more coherent explanations.

Novak (1993), proposed a model of learning known as *Human Constructivism*. Human constructivists assert that the cognitive processes resulting in creative or research work of a scientist are essentially the same as those of a fresh learner in constructing new knowledge. In both cases individuals construct meanings by forming connections between new concepts and those that are part of an existing framework of prior knowledge. It is this meaning-making mechanism, embodied in a complex set of

language symbol systems that is the essential adaptation of the human species.

Novak's human constructivism is a comprehensive effort that synthesises constructivist view of learning deriving from a cognitive theory of learning with an expansive epistemology, and provides useful tools for classroom teachers. In this model, Novak seeks to find unity among the processes of meaningful learning, knowledge restructuring and conceptual change. According to human constructivists, much of learning is gradual and assimilative in nature. It is caused by a cognitive process called *subsume* and results in a 'weak' form of knowledge restructuring and an incremental change in conceptual understanding.

In addition, however, successful scientists and students often experience insightful moments that trigger a significant and rapid shift in conceptual understanding. This shift is a product of a radical or 'strong' form of knowledge restructuring that results from superordinate learning. The product of this meaning-making exercise is a strongly hierarchical and cohesive set of interrelated concepts, a conceptual framework.

Human constructivists reject the view that knowledge is a product that can be faithfully conveyed by 'teachers'. Instead, knowledge is an idiosyncratic, dynamic construction of human beings. Human constructivists assert that no two human beings, scientists included, construct precisely the same meanings even when presented with identical objects or events. Novak (1993) stated that "the almost infinite number of permutations of concept-concept relationships allow for the enormous idiosyncrasy we see in individual concept structures, and yet there is sufficient commonality that discourse is possible and sharing, enlarging and changing meanings can be achieved. It is this reality that makes possible the educational enterprise".

1.4 Curriculum Transaction In Constructivist Paradigm

Constructivism is not an educational fad; it is a major rethinking about the teaching and learning process that will have a lasting impact on both curriculum and instruction. Constructivism provides a 'new theory of learning' and also a 'new theory of teaching'. This theory calls for a major shift from teacher-centered direct instruction towards student-centered understanding-based teaching. The traditional methods of teaching consider teaching as transmission of facts to students

who are considered passive receptors. In such classrooms, lecture method predominates and teachers stress on completing the voluminous syllabus. Teacher-student relationships are characterised as distant, where teacher is the authority figure. Teacher is also seen as authority of subject content, who has the 'right' knowledge.

In contrast to traditional conceptualisation of teaching, constructivist teaching considers the student as an active learner and the teacher as a guide in the learning process. The theory of constructivism is based on the idea that children learn better by actively constructing knowledge and by reconciling new information with previous knowledge. The question of how curriculum can be transacted effectively is closely related to what curriculum should be taught and considered under the constructivist paradigm. This section discusses the curriculum and curriculum transaction practices in a constructivist classroom.

1.4.1 Constructivist Curriculum

In the construction of curriculum, a 'top-down' approach is generally followed. In this traditional approach, an 'expert' is believed to have the best knowledge, and therefore, the expert determines what should be taught. This 'authoritarian' model of curriculum poses many problems because the same curriculum is implemented across many differing contexts. In some states, the same textbooks are adapted, without taking into account the differing cultures and contexts in which students operate. Many students do not see the relevance and need of learning facts that some remote authority has included in the syllabus and textbooks. Consequently, schools alienate learners by isolating the facts from the context from which they arose and in which they are useful.

This authoritarian model of curriculum also poses problems for the teachers because teachers find it difficult to present the isolated facts to students. Since they cannot relate these isolated facts to their environment or context, they are left with no alternative but to state facts directly. Students, too, have to believe and learn these facts as 'right' knowledge. In this model, teacher or text books are taken as authority and students assume that teachers have all the knowledge and students look to them for the 'right' answer.

In contrast to objectivist view, the constructivist perspective places emphasis on providing students with opportunities to develop skills and knowledge, which they can relate to their prior knowledge and future utility. In the constructivist curriculum, the individual learner has an important role in determining what will be learned. The teacher decides with others as to what learning in relevant, useful and important to the learner. Students also explore the means to learn. Students work in groups and discuss their problems and solutions. Teachers, instead of teaching a multitude of facts, teach processes of thinking and constructing relationships. Students learn skills in the particular context and therefore, can use their learning to solve problems within their particular culture.

The teacher, operating from constructivist paradigm, is an investigator, trying to understand how his/her students are constructing knowledge. They respect students' ideas and try to understand their alternative solutions to a problem. Students also view them as only one of the sources of information. They do not view knowledge as absolute and unchanging. They view it as adaptive and ever changing and explore the ways to construct knowledge. Teachers also realise that knowledge/ concepts learned today may change/modify tomorrow. Therefore, they do not stress on memorising the facts by students but help them in developing confidence and adaptability.

1.4.2 Constructivist Teaching

Constructivism was earlier viewed as a theory of learning, rather than a prescription for teaching methods. But now, constructivist teaching is an active reform issue and researchers have started experimenting and reporting the instructional practices which help teachers to nurture students as independent thinkers and constructors of knowledge.

Constructivism is based on the belief that learners actively create, interpret and reorganise knowledge in individual ways. These fluid intellectual transformations occur when students reconcile formal instructional experiences with their existing knowledge, with the cultural and social knowledge and contexts in which the ideas occur and with a host of other influences that serve to mediate understanding.

The instructional strategy, based on this belief, suggests that students should participate in experiences that accommodate

The process of learning starts with the action and then analysing the effect of that action. Learner would then reflect upon and provide adequate explanations. Generalisation and development of theory may involve action over a range of circumstances and expressing the results in a symbolic form.

The learning styles based on the four steps of experiential learning can be described as converger, diverger, assimilator and accommodator. Experiential learning allows for divergent learning styles in the classroom.

2.6.2 Problem Solving

The second important approach within the learner centred framework is problem solving. The problem solving approach has several advantages over expository methods. It helps in developing higher cognitive abilities of thinking rationally as well as transfer and application of knowledge to new situations. Learning through problem solving is more meaningful, permanent and transferable compared to learning through traditional expository methods.

In the problem solving approach, students are active participants in the construction of new knowledge whereas in traditional methods, students are passive receptors of knowledge. In problem solving, students formulate hypothesis, suggest alternate solutions, conduct experiments, draw generalisations, compare their findings and results with those of others, verify and validate their own ideas whereas through traditional methods of lecture, reading or recitation, students receive existing knowledge. Through problem solving approach students develop the thinking, observational and enquiry skills.

2.6.3 Investigatory Approach

Investigatory approach develops the abilities to formulate hypotheses, measuring, planning, enquiry and communication. The steps involved in investigatory approach are posing useful questions, planning out investigation, hypothesising, predicting and evaluation. This approach is particularly helpful in learning natural science and social science subjects.

2.6.4 Concept Mapping

Concept mapping for meaningful learning is another emerging method in learner centred framework. Concept mapping is

particularly useful in learning about the structure of knowledge and understanding the process of knowledge construction. It involves meta-learning, that is, learning about learning. Concept mapping uses three types of knowledge facts, concepts and generalisations. The steps involved in concept mapping are selecting the key concepts and sub concepts, linking the concepts and sub concepts through prepositions and making meaning out of horizontal and vertical linkages. Concept maps help in understanding the existing concepts of the learners. These can also be used to diagnose the misconceptions of students.

2.6.5 *Social Inquiry Approach*

Social inquiry is a useful learner centred approach. This approach requires students to collect data, analyse and interpret data, draw generalisations and develop theories and concepts on the basis of empirical research-based data. Field survey and research involves community participation.

2.6..6 *Creative Writing*

The learner centred method that can be used to develop cognitive and affective abilities of a higher order among students is creative writing. This method can be used to teach all subjects like language, science, social science and mathematics. Creative writing helps in developing abilities of reporting, arguing, explaining, persuading, reflecting, coping and evaluating. Creative writing allows free expression of thought, feelings and emotions.

Learner centred approaches include all those methods where learner's own initiative and efforts are involved in learning.

2.7 Summary

Classroom processes, particularly teaching-learning strategies, have been considered important for improving the quality of education in our schools. There has been increasing shift from 'teacher centred' to 'learner centred' approaches of teaching. The NCF (2005) developed by NCERT emphasises the use of learner centred approaches at the secondary stage. Learner centred approaches take into account learner's capabilities, capacities, learning styles, context and culture. They are supported by philosophical assumptions and have strong psychological basis. These are based on constructivist philosophy that views knowledge as subjective and contextual.

these ways of learning. Such experiences include inquiry activities, discovery, problem-solving, discussions with peers and teachers, collecting and interpreting information from different sources, expressing their understanding in diverse ways, applying and validating their understanding in new ways etc. Teachers must provide authentic learning situations, complex learning environments and facilitate negotiations.

Before teachers apply these practices in the classroom, they must understand that these cannot be grafted on traditional methods of teaching; these need a change in the culture - a set of norms, attitudes, beliefs and practices that constitute constructivist culture. The teacher's role is not to fill the empty vessels with superfluous knowledge, but it is to guide children to make sense and meaning of their knowledge and to give rational explanations of their knowledge.

Role of Teacher: In the constructivist classroom, the role of teacher changes from 'transmitter' of knowledge to 'facilitator' of knowledge construction. Teacher must know the pre-concepts and misconcepts of children. Teacher's activities may be such that help the children in clarifying ideas, providing rational explanations, challenging misconceptions, guiding experimen-tation, predicting results and drawing inferences. Teachers should ask questions which test students' ideas and provide feedback to them. They should be encouraged to debate ideas and also comment on answers and explanations provided by other students. Teachers may ask students to use evidence to explain ideas, to apply their conceptions to phenomenon, to summarise results and to present them symbolically. Teachers should encourage students to think independently, provide logical explanations, test hypothesis etc.

The new role of teachers also places new demands on teachers. Teachers should have flexible subject-matter knowledge. That is, the teacher must not only have good understanding of the principles but should also have the ability to explore these principles in a variety of ways. For example, if a teacher is teaching the 'concept' of density in the classroom, some students may understand it better by relating the role of density in the visibility of an iceberg or the sinking of a ship. Another group of students may approach the problem from a

purely abstract, and mathematical perspective. Teacher, in such a situation, must be intellectually agile, able to apply his/her mathematical understanding of density to real life complex situations. In mathematics most of the problems have one 'correct answer' but students may reach this answer through different processes. Teacher has to examine how the students make use of the problem solving approach. Teacher should have awareness of disciplinary 'truths' and the viability of various ways of knowing the 'truth'.

In addition to good knowledge of subject-matter, teachers should have good knowledge of 'pedagogical skills'. Designing instructions based on 'constructivism' is not as straightforward as it appears. Teachers and teacher educators struggle with how specific instructional techniques (for example, lecture, discussion, cooperative learning, problem-based learning, inquiry learning) fit in the constructivist model of instruction. Regardless of the particular techniques used in instruction, students will always construct and reorganise knowledge rather than simply assimilate information from teachers or textbooks. The question is not whether to use lecture or discussion or discovery methods but how to use these to nurture students' thinking. Constructivist principle suggests that students should experience the idea, phenomena and artifacts of a discipline before being exposed to their formal, theoretical explanations. For example, the science instruction may start with manipulations of a pendulum or observing a clock pendulum on the wall; mathematics instruction may start by constructing polygons. Only after these experiences should the students be asked to provide explanations and conceptual organisation.

Constructivist classroom is characterised by problem-based activities. Teachers must employ a range of strategies to support individual student's understanding. Eventhough designing instruction is important in constructivist teaching, sequencing of content depends more on the student's responses. The lesson develops on the student's pre-concepts, sequence and direction of conceptual change. The challenge for the teacher is to select the proper strategy and implement it skillfully. Student collaboration and participation in teaching-learning process should be encouraged.

Student's Role: Students' role in the constructivist classroom changes from 'knowledge acquisition' to 'knowledge construction'. Student questions teachers and other students' ideas, gives predictions about phenomenon, designs experiments to test his/her own ideas, formulates and tests hypothesis and discusses results. He/she compares the findings and results with those of others and draws independent conclusions, applies the new concepts to familiar situations and familiar concepts to new situations. The student verifies and validates his/her own beliefs and ideas, demonstrates solutions and procedures and elaborates and interprets ideas from the text. Students develop the habit of self-directed learning. Students take the responsibility of their own learning.

Constructivism allows academic freedom to students, encourages cooperative learning and sharing of thought among peers. Students can also work on independent projects. Teachers in a constructivist class also have the challenge of managing such a decentralised learning environment.

Class Management and Organisation: In the traditional classroom, teacher is the controller of class discipline whereas in a constructivist classroom, teacher is a leader of the democratic learning group. Pupil collaboration is the 'keyword' in the constructivist classroom. For effective collaboration, each student should be engaged in a cognitive task and should be provided continuous reinforcement.

For effective management, the teacher can divide a class into manageable groups. Each group is assigned a specific task or the group can select a problem, negotiating with the teacher. The teacher should provide feedback by discussion with the group. Teacher must see that all students in the group participate in the learning. For organising and conducting group activities effectively, the teacher should provide opportunities to all students to become actively involved in the learning task.

The teacher should provide learning tasks with cognitive focus. Effective use of group work requires careful planning and organisation. Following suggestions may be tried out for effective group work.

- Students should be provided some orientation and training for working in groups. They should practise listening to others' ideas, giving their comments, respecting others' ideas,

thinking about and experimenting with others' ideas. Sharing of ideas should be encouraged and practised. Students should have the practice of moving in and out of the groups quickly.

- Students should be seated at proper positions in the group prior to starting the group work. The transition from whole-class activity to student groups and back again should be accomplished with minimum of disruption.
- Students should be given clear and specific tasks to accomplish in the groups.
- Teacher should also specify the time within which students have to accomplish the task.
- Students should be required to produce a product as a result of group work.

Effective management requires that all students should have specific and meaningful tasks. There should be no loss of time in transition from whole class to groups and back. Clear directions, specific problem, allotment of specific time and continuous monitoring make group work more effective. Students should be encouraged to record their observations, debate the points of contrast and draw meaningful explanations. Though monitoring is a part of class management, it is useful in showing the right direction and providing the feedback. Feedback through evaluation is an important part of classroom transaction.

Evaluation: Constructivism requires a re-examination of the classroom evaluation practices. Traditional teachers emphasise too much on marks/grades and the position secured by a student in the class. They depend on standardised tests and test scores for determining the success of a student in the prescribed course. These practices, however, have come under fire for a multitude of problems. The first problem raised by teachers themselves is that this system has resulted in teaching how to answer the questions instead of using the tests to know the success of teaching-learning process. Secondly, the correlation between test scores and students' abilities is low in many cases.

The present practices of evaluation are based on 'objectivist paradigm'. The technology of testing in this paradigm was evolved to determine whether students could reproduce facts and determine correct answers to problems. The test makers are viewed as having the 'correct' answers and student knowledge is judged against the test constructor's knowledge. The present

testing practices consist of 'objective' questions to eliminate teacher's subjectivity in scoring. The questions are constructed by the test designer and the wordings are of the test designer. The students are expected to interpret the questions as they were designed by the examiner. In multiple-choice questions, they again have the limitation to select the correct answer from among those supplied by the examiner.

Students may frame or interpret a problem differently. They may like to give an answer, which is not one of the suggested answers given by the examiner. In the objectivist paradigm, alternative solutions or alternative understanding of words are not considered in assessing the answers, although those solutions may be viable. Objective tests, therefore, do not reveal what a student knows/thinks, but only reveal how well his/her knowledge matches with that of the test maker. From a constructivist perspective, evaluation of student learning should not be judged only on the specifics of the knowledge, but should be judged on whether students can solve the problems posed with a viable solution.

Techniques which attempt to reveal the individual's construction of knowledge are being explored and tried out. In the constructivist paradigm uniform standards of evaluation cannot be used for all students. Self evaluation against one's own previous knowledge may be used. A 'criterion-based' evaluation must be used. For assessing conceptual change, different methods of assessment can be used such as concept mapping and vee diagrams. Performance-based tests, portfolios, team-projects and so on are some of the techniques which can be used in the constructivist paradigm.

Concept maps of a student drawn on pre-and post-instructions give valuable information on 'conceptual change/modification'. Teachers using concept mapping as evaluation tool may have some problems in quantifying their evaluation of student learning. There is need for further research on identifying and developing valid and viable ways of assessing student's construction of knowledge.

1.5 Summary

Constructivism as a philosophy has a long history. Theorists like Dewey, Montessori, Gandhi, Piaget and Vygotsky were all constructivists at root. These theorists, however, failed to bring

about educational reforms because they could not relate these to classroom teaching practices. Piaget believed that children construct knowledge on the basis of their prior knowledge by the process of adaptation. For Piaget, the construction of knowledge is individual; culture and language are used only to give meaning to the abstract concepts constructed by individuals. Vygotsky believed that social interaction is important for construction of knowledge and individuals construct knowledge in the social and cultural context in which she/he is embedded. Both these theories remained more as theories of learning.

In the 1980s and 1990s researchers like Driver, Novak, Posner and Van Glaserfeld conducted a number of experiments on classroom constructivism. Empirical data from these research studies revealed that classroom interaction helps in the construction of knowledge.

Constructivist paradigm calls for a change in the classroom culture, attitudes, beliefs and practices. Role of teacher in this paradigm shifts from 'transmitter' of knowledge to 'investigator' and 'explorer' of knowledge. Role of student changes from 'knowledge acquisition' to 'knowledge construction'.

In the constructivist classroom, student designs experiments, tests hypothesis, draws conclusions, compares his findings and results with those of others. In the constructivist classroom, teacher is the manager and organiser of the class whereas in the objectivist classroom teacher is the controller of the class. Evaluation methods also change from objective standardised tests to performance-based tests, concept mapping and vee diagrams. Constructivist paradigm is a new culture, a new environment in the class.

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Constructivists believe that learners construct new knowledge using their prior knowledge in the particular context in which the cognising individual is operating. Learners are active participants in the construction of knowledge. Learning is thus not a passive receptive process and knowledge cannot be transmitted to passive learners. Learning is an active meaning-making process where learners reformulate the new information, restructure their existing knowledge and reorganise their prior conceptual schemes.

Learner centred approaches stress the importance of enquiry, observation, action, investigation, formulating hypothesis and evaluating new ideas and theories. The methods that can be used in a learner centred classroom include experiential learning, problem solving, investigative projects, concept mapping, field survey and research, creative writing etc. Learner centred classes have scope for divergent learning styles. In order to effectively use these approaches, teachers must understand the learners, their prior experiences, learning disposition, context and culture. Learner centred methods cannot be grafted on traditional methods and require a change in the classroom culture.

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2

Learner Centred Approaches

2.1 Rationale

In recent years the quality of education in schools and especially the effectiveness of teaching and learning have drawn the attention of educational policy planners and practitioners. Researches conducted by NCERT and other research institutes in the context of Minimum Levels of Learning (MLL), District Primary Education Programme (DPEP), Mid Term Assessment Surveys and Achievement Surveys indicate that attainment of students in primary schools is much below the desired levels. Similar is the situation at the secondary stage as reflected in the results of examinations conducted by various boards of examinations. In some board examinations, the failure rate is as high as 60 percent or more. These results reflect the poor quality of learning and teaching in our schools. Parents, teachers, students, educationists and politicians are all dissatisfied with the quality of teaching and learning in schools and have demanded radical changes in the nature and structure of curricula, teaching strategies and assessment procedures.

The Jomtien Conference (1990) discussed issues and challenges facing education and shared consensus on what is required to address these challenges to education. The recommendations of the Jomtien Conference addressed the issues of 'access', 'quality; 'relevance', 'equality', 'gender' and 'efficiency' of education. It suggested a change in approach to education, from 'individual to collaborative' and recommended a pedagogical shift from 'teacher centred to learner centred' approaches. The Jacques Delors Commission Report (1996) on 'Education For The Twenty First Century' proposed that the education system should be characterised by *learning to be, learning to learn, learning to do and learning to live together*. It

recommends learner centred approaches to achieve these objectives of education.

Considering the changing needs of the learners and the society, the National Council of Educational Research and Training (NCERT) developed National Curriculum Framework (NCF) in the year 2005. The NCF(2005) emphasises 'learner centred approaches' to achieve the objectives of the curriculum.

The curricular content and its transaction must be relevant to the learners and should help them to become constructors of new knowledge and life long learners. For this, a pedagogical shift is required from teacher centred to learner centred teaching and from examination oriented to learning oriented evaluation.

This chapter discusses the concept of 'learner centred' teaching, how teachers can understand the learners and why it is important to know the learners. The scope of learner centred approaches and selection of appropriate strategies have also been discussed.

2.1.1 Objectives

After reading this chapter, you will be able to

- understand the concept of 'learner centred' approaches;
- identify the factors influencing learning and learners;
- understand why it is important to understand the learners; and
- identify various learner centred approaches.

2.2 Introduction

The history of research on 'teaching effectiveness' reveals that there has been increasing shift from 'teacher centred' teaching methods to 'learner centred' classroom procedures. Until the 1950s, researches on 'teaching' focused on two themes – firstly, the 'methods experiments' where researchers compared the relative merits of using one method of teaching a particular subject with another method and secondly, exploring the personal characteristics of the 'good teacher'. By the 1960s, it was increasingly recognised that teaching could not be described or prescribed in terms of standardised methods. It was also accepted that good teachers could not be distinguished by any kind of distinctive personality profile alone. It was realised that to understand teaching, one needs to study 'what happens in the classrooms'.

In the 1970s, the dominant model of research into 'teaching effectiveness' was the 'process-product' model, where the researchers examined the correlation between the product (a measure of achievement) and the process (a measure of classroom activities). The processes were studied more in terms of teacher craft, that is, teacher's knowledge, skills and strategies. In the mid-1970s, researchers began to use social scientific theories to understand the classroom processes.

By the 1980s, it was recognised that in classroom processes, learners craft, that is, learning strategies, prior knowledge, skill and context of the learner are as important as teacher craft. During the 1980s and 1990s, constructivist movement gained momentum and researchers like Posner (1982), Driver (1983), and Novak (1984) conducted a number of studies on 'how children construct knowledge and how teachers can provide interventions to help children construct their concepts'. These researches also emphasise the active role of the learner in the teaching-learning process.

2.3 Concept of 'Learner Centred' Approaches

Traditionally it is believed that students learn from teachers and it is the teacher's responsibility to ensure that students learn. Teachers are classified as good teachers or bad teachers depending on the kind of examination results they produce or the achievements of their students.

Earlier researches also focused on teacher strategies or teacher activities in the classroom. Till the 1970's, teachers were considered the main actors in the classroom and little attention was paid to how pupils engage in classroom learning and how students' thinking, experiences and learning strategies contribute to learning. By the 1980s, many researchers had recognised that in order to understand the effects of classroom teaching upon pupils' achievements, one needs to understand the pupils' thought processes. However, the studies conducted on pupils, thought processes during this period also focused on teachers and as Wittrock (1986) pointed out, most of the studies on pupils' thought processes studied the effects of teachers and instructions upon students' perceptions, achievement, attitudes, meta-cognitive processes, motivation and understanding.

Teachers were still seen as the main actors in the classroom and effects of their teaching on pupils' learning were studied

Even the studies on pupils' learning strategies emphasised 'teaching pupils to use appropriate learning strategies' (Weinstein and Mayer 1986; Wang and Palincsar 1989). These researches threw some light on the fact that students bring with them knowledge and experiences which influence classroom teaching-learning processes.

As pupils grow older and become more experienced in classrooms, they develop their own strategies for learning. Researches indicate that students of secondary stage tend to make use of more sophisticated learning strategies such as organising material for meaningful learning, production of their own imagery to relate to what they are seeking to learn and use of rehearsal for memorising information.

The extent to which pupils are aware of their own learning strategies also seems to be related to the effectiveness of their learning. Wang and Palincsor (1989) summarised the research finding in this area as follows:

> Research suggests that the amount of effort that students are willing to put into a learning activity and their degree of persistence is determined by their expectations regarding success and failure, the value they give to the activity and the extent to which they believe that their own strategic effort influences the outcome. An increase in a student's sense of personal control can lead, in turn, to greater self responsibility, achievement, motivation and learning.

Pupils' knowledge about their learning processes and their control over these processes are elements of 'meta-cognition'. Meta-cognition plays an important role in pupils' learning. The pupils' understanding of the material they are trying to learn has consistently been shown to be related to the extent of their use of strategies for monitoring their own understanding of the material (Weinstein and Mayer). These researches suggest that in the classroom, learner is the main actor and learning depends on learner's strategies. From these researches we can derive that:

> The 'learner centred' approaches place learner at the centre of classroom processes. These take into account learner's developmental stages, maturity, learning strategies, meta-cognitive and cognitive skills, prior knowledge and experiences, motivation and interests, personality, context and culture.

For implementation of the learner centred approaches, teachers must understand the learners and their learning styles.

2.4 Understanding The Learner

In order to use the learner centred approaches, the teacher must understand various aspects of learner development such as cognitive and meta-cognitive skills, culture, personality; motivation and learning styles. This section discusses the processes of learner development which the teacher must understand for selecting appropriate learning experiences.

2.4.1 Health and Physical Development

Learners' capacity to learn depends upon their health and stage of physical development. Learners develop physically at different rates and the stage of development affects their capacity for new learning and self-confidence. Teacher must take into consideration differential rates of development of learners while selecting the learning experiences. Regular medical check-ups may provide some feedback to teachers about learners' health and physical development. Health is also influenced by social and environmental factors. During training programmes, the need for healthy, hygienic, stress-free school environment conducive for learning may be impressed upon the teachers. Schools may also provide physical development programmes for students such as exercises, yoga, sports etc.

2.4.2 Mental abilities / Intelligence

Teachers can meet the specific needs of students by knowing their specific mental abilities. Sometimes teachers use general terms such as 'intelligent', 'bright', 'able' or 'clever' to describe students in a classroom grouping and also learning tasks are according to this kind of classification. However, these terms are differentiated imprecise and unreliable and do not help in selecting the appropriate learning experiences. Gardner (1985) suggested that there are 'multiple intelligences' or 'mental abilities' such as:

- Linguistic: enables individuals to communicate and make sense of the world through language.
- Logical mathematical: allows individuals to use abstract relations.
- Visual spatial: makes it possible for people to visualise, transform and use spatial information.

- Bodily kinesthetic: enables people to use high levels of physical movement, control and expression.
- Musical: allows people to create, communicate and understand meanings made from sound.
- Intra-personal: helps people to recognise and make distinctions about others' feelings and intentions and respond accordingly.
- Inter-personal: enables the capacity for reflective understanding of others and oneself.

Gardener's analysis of specific mental abilities suggests that students have different kinds of abilities and potentials and teachers must select diverse learning tasks to develop these abilities. Teachers can thus influence the quality of pupil learning and can enhance the intellectual capacities of learners.

2.4.3 Culture

Learning is a 'meaning making' process where learner makes sense of the new information/learning material on the basis of his/her previous experiences/learning. The culture of school, home, peers and social environment as a whole influence how children learn. The cultural influences on learning can be due to cultural experiences, the mediation of language and learning disposition.

(i) Cultural experiences

The previous learning/experiences of the learner are strongly influenced by the culture, knowledge, values and ideas of the social group in which the learner is situated. These provide the initial framework for understanding the new learning material and thus influence the new learning.

(ii) Language

Language is the medium of thinking and learning. Language also embodies the cultural tools through which new experiences are interpreted and mediated when learners interact in their communities and societies. Language is created, transmitted and sustained through interaction with other people within the cultures of communities or social groups. Thus language as a 'cultural tool' and medium of learning influences the new learning, that is, the process of 'making sense'.

(iii) Learning disposition

Learner's disposition, that is, whether learner is open or closed to outside support, confident or fearful, self regulated or dependent, defensive or willing to take risks, influences learning. Learner's self belief, self identity and self esteem are formed in the cultural and social settings in which the learner is situated. Learning dispositions are therefore formed by the cultural and social settings and influence the learning of learners. The major sources of such cultural influences are family, community, peers, school and the media.

(iv) Family

Influence of family on learning achievement has been recognised for many years. The influencing factors are not only the social status, income and material things but also the schooling concerns that the culture of the family provides. Inputs in terms of language and interaction for further development and learner's disposition regarding learning also influence the learning. Relationship with parents, siblings and mother care are the most important factors which influence learning. The emotional support provided through maternal nurturing which Reay (2000) termed as 'emotional capital' is the most significant factor influencing learning. In modern society, the family forms are very diverse such as both working parents, single parent families, joint family, one child family etc. The learner's cultural circumstances due to the family structure and support thus vary widely.

(v) Community

India has diverse community cultures due to language, region, religion, caste and social variations. Each community based on language, for example, has many sub communities based on religion, caste, social status and region. Each sub community has its own culture and values. These influence learning and construction of understanding.

(vi) Peers

The influence of peers in school setting is considered here. Peer group culture is important to learners as way of learning, enjoying and adapting to school life. At secondary stage, boys and girls tend to form separate social groups. Within a school or even a class, sub cultural groups based on language, region, religion,

caste, social class and educational achievement are also formed. These peer groups influence achievement and self esteem of students. Some peer cultures favour school attainment and are likely to reinforce teacher efforts towards a positive approach to learning. Other peer cultures derive meaning from alternative values and students influenced by such cultures approach school with minimum expectations. These students still construct understanding and 'make sense' of the learning material but it may not be of the type the teacher would have aimed at.

(vii) The School

Each school has its own unique culture created by those who are associated with it. School culture may also be seen as the learning context characterised by the language in which teaching and learning is transacted, social-cultural background of the teachers and students, values of the school etc. School culture determines what the assumptions underlying learning are, what the criteria for 'success or failure is, what kind of values are imparted through symbolic rituals, assemblies and cultural functions and so on. Are students allowed self-directed learning or encouraged to take risks?

It is important to recognise that school culture does not influence all students in the same way. Similarly school culture may not have the same kind of influence on all the teachers. Some teachers may feel that the cultural milieu inhibits the kind of teaching approach they favour, whereas other teachers may find it enabling and supportive. Another factor influencing the learners is the existence of subcultures within the school. Each school has its own distinctive culture but a closer inspection of school culture would reveal that there are many subcultures in the school. These cultural groupings among staff and students may be based on region, language, religion, caste, socio-economic status and so on. This homogeneity influences the classroom practices and learning achievement of learners.

(viii) The Media and Technologies

Students of secondary stage spend hours watching television or listening to radio. Students learn from TV and radio programmes as many of these are educational in nature. Some students have special interest in some particular programmes such as *Discovery*, *National Geographic*, news, sports etc. These programmes give them opportunity to know more than what is

taught in school and what they read in books.

Other programmes and advertisements also influence students' knowledge, lifestyle etc and many young people tend to adopt particular behaviour or consumption patterns associated with celebrities or popular music. The new technologies of computer, internet and cell phone have increased the interactive activities of students. Now they can access knowledge through different sources and can interact with people around the world using these new technologies. Many schools provide such opportunities of using and learning from computers, internet etc. Media and technologies influence students' learning. At the same time students also need to be protected from misuse of the media and technologies.

2.4.4 *Personality And Learning Styles*

Understanding the personality of the learner will help teachers in recognising patterns of individual differences and in selecting the teaching strategies according to the individual's personality and learning style. Different theories of personality and their analysis to predict individual cognitive and learning styles may have been learnt. Teachers most frequently use the 'lay perspective' to analyse students' personalities. This 'lay perspective' is evident in everyday actions of people, where people judge other persons' personality, anticipate their actions, interpret their ideas, understand characters, predict and explain behavior on the basis of 'common sense' and so on.

The second kind of personality analysis is based on 'trait theories'. The most frequent classifications based on 'trait theories' are impulsivity/reflexivity (Kagan, 1964) and extroversion/introversion (Eysenck, 1969). Trait theories attempt to identify personality dimensions and to objectively measure the resulting cognitive and learning styles. Riding and Rayner (1998) synthesised 'trait theories' to arrive at the orthogonal families of learning styles - wholistic/analytic and verbal/imager. Butter (1998) offered a more general classification of learning styles such as the concrete/abstract/sequential/random. Sarasin (1999) classified cognitive styles as visual/auditory/tactile. These classifications based on trait theories help in recognising patterns of individual differences but it is not straightforward to translate these into specific classroom provisions.

The process of learning starts with the action and then analysing the effect of that action. Learner would then reflect upon and provide adequate explanations. Generalisation and development of theory may involve action over a range of circumstances and expressing the results in a symbolic form.

The learning styles based on the four steps of experiential learning can be described as converger, diverger, assimilator and accommodator. Experiential learning allows for divergent learning styles in the classroom.

2.6.2 Problem Solving

The second important approach within the learner centred framework is problem solving. The problem solving approach has several advantages over expository methods. It helps in developing higher cognitive abilities of thinking rationally as well as transfer and application of knowledge to new situations. Learning through problem solving is more meaningful, permanent and transferable compared to learning through traditional expository methods.

In the problem solving approach, students are active participants in the construction of new knowledge whereas in traditional methods, students are passive receptors of knowledge. In problem solving, students formulate hypothesis, suggest alternate solutions, conduct experiments, draw generalisations, compare their findings and results with those of others, verify and validate their own ideas whereas through traditional methods of lecture, reading or recitation, students receive existing knowledge. Through problem solving approach students develop the thinking, observational and enquiry skills.

2.6.3 Investigatory Approach

Investigatory approach develops the abilities to formulate hypotheses, measuring, planning, enquiry and communication. The steps involved in investigatory approach are posing useful questions, planning out investigation, hypothesising, predicting and evaluation. This approach is particularly helpful in learning natural science and social science subjects.

2.6.4 Concept Mapping

Concept mapping for meaningful learning is another emerging method in learner centred framework. Concept mapping is

particularly useful in learning about the structure of knowledge and understanding the process of knowledge construction. It involves meta-learning, that is, learning about learning. Concept mapping uses three types of knowledge facts, concepts and generalisations. The steps involved in concept mapping are selecting the key concepts and sub concepts, linking the concepts and sub concepts through prepositions and making meaning out of horizontal and vertical linkages. Concept maps help in understanding the existing concepts of the learners. These can also be used to diagnose the misconceptions of students.

2.6.5 *Social Inquiry Approach*

Social inquiry is a useful learner centred approach. This approach requires students to collect data, analyse and interpret data, draw generalisations and develop theories and concepts on the basis of empirical research-based data. Field survey and research involves community participation.

2.6..6 *Creative Writing*

The learner centred method that can be used to develop cognitive and affective abilities of a higher order among students is creative writing. This method can be used to teach all subjects like language, science, social science and mathematics. Creative writing helps in developing abilities of reporting, arguing, explaining, persuading, reflecting, coping and evaluating. Creative writing allows free expression of thought, feelings and emotions.

Learner centred approaches include all those methods where learner's own initiative and efforts are involved in learning.

2.7 Summary

Classroom processes, particularly teaching-learning strategies, have been considered important for improving the quality of education in our schools. There has been increasing shift from 'teacher centred' to 'learner centred' approaches of teaching. The NCF (2005) developed by NCERT emphasises the use of learner centred approaches at the secondary stage. Learner centred approaches take into account learner's capabilities, capacities, learning styles, context and culture. They are supported by philosophical assumptions and have strong psychological basis. These are based on constructivist philosophy that views knowledge as subjective and contextual.

The third strand of personality analysis which has become prominent in recent years is 'self perspective'. This approach sees the development of personality in class association with that of self-image and identity. It is based on the individual's capacity to reflect on himself/herself, to take account of the views of others and to develop. In this perspective, the social context in which students grow and learn is important as it influences their self concept and consequent patterns of action.

The learning styles are thus influenced by learning situations, experiences and motivation. Learning styles may be regarded as a link between the personality and cognitive behavior of the learner.

2.4.5 *Motivation*

Another important factor in learning is motivation. Motivation is related to whether the learning experiences provided to the learners match with their personality and learning styles or not. If students are provided with learning tasks that challenge the existing skills, knowledge and understanding, then students may feel motivated to do the task. But if the learning task provides too little or too great a challenge to the existing skills, knowledge and understanding, then boredom or mischief may ensue.

Teachers require understanding of each learner's capabilities, capacities, interests and also considerable skill and knowledge of the subject in order to provide effective learning experiences to motivate the students. Motivation can be 'intrinsic' and 'extrinsic' depending on the personality of the learners and meaningfulness of the learning tasks. Motivation is less if students find curriculum irrelevant and unrelated to their lives. On the other hand, if students could relate learning experiences to their personal development and understanding, motivation is more.

If curriculum is too theoretical and abstract, students of secondary stage may find it superficial and unrelated. They may study such a curriculum only to pass the examination or to satisfy some other short-term goals. Retention is less in such circumstances. Deep enduring learning only occurs when new knowledge connects meaningfully with the personal narratives through which we make sense of life. Motivation is also related to whether the learning task is emotionally challenging and satisfying or not. Emotions are subjective responses to events

that are important to individuals. A learning task may pose a threat or affirmation to the previous understandings and 'meaning structures' of the learners which may be reflected in their negative or positive emotions.

A learning activity may also pose a threat or affirmation to the personal identity, self-esteem or social status of the learners. The learning task, therefore is not only cognitively or rationally challenging but is also emotionally challenging. For students success can be encouraging and embracing while failure can be discouraging and humiliating. Success and failure in turn are related to the magnitude of cognitive and emotional challenge that a learning task poses for the learner. Learning can thus be stressful at both the macro-level of the task and at a more enduring personal level. To meet these challenges of learning, students will have to become more effective at 'learning how to learn'.

2.4.6 *Meta-cognition and thinking skills.*

Meta-cognition is the capacity for self-awareness regarding one's own actions or mental power. Meta-cognition is particularly important at secondary stage when learning becomes more teacher directed. In secondary schools, thinking is challenged to become more disciplined and deliberate; tasks are set, problems posed and instructions given; criteria for success and failure become more overt. The result of all this is that a new degree of self-control is required and, in order to achieve this self-control, new forms of reflective self-awareness become essential.

Vygotsky also believed that learners would be supported by their self-regulation in addition to the assistance offered by teachers and peers in crossing their 'zones of proximal development'. Here school instructions can help students in raising self-awareness. Meta-cognition also helps in developing higher order thinking abilities. Psychologists and innovative practitioners believe that thinking can be developed among students through curriculum work.

Several programmes such as Cognitive Acceleration through Science Education (CASE) (Adey and Shayer, 1994) and CAME have been successfully adapted for teaching science and mathematics at the primary stage. Similar more 'thinking programmes' can be developed for secondary stage students,

who have better self-regulation and disciplined thinking. Basic thinking skills of problem solving, information processing, reasoning, enquiry, creative thinking and evaluation can be developed through teaching of various curricular subjects. The teaching strategies that can be used to develop thinking skills include problem solving, investigative projects, creative writing, field surveys and experiential learning. One must discuss with other teachers what kind of thinking skills are required to make learners better thinkers, who can learn meaningfully, think flexibly and make reasoned judgments. How these thinking abilities can be developed among students directly or through curricular areas also need to be discussed in the training programmes for the teachers.

2.5 Learner as Constructor of Knowledge

The constructivist philosophy views knowledge as contextual and subjective. It cannot be transmitted to passive learners. Knowledge is always the result of a constructivist activity and students construct knowledge in the particular context in which the cognizing individual is operating. Constructivism provides a new theory of learning and also a new theory of teaching where learner is the main actor.

Constructivists like Driver and Easley believed that children construct knowledge by reconciliation of new information with their prior knowledge. Piaget's view of constructivism is based on the developmental stages of the learner. He believed that individuals construct knowledge individually based on past experiences and through adaptive process. Vygotsky on the other hand believed that construction of knowledge occurs through interaction in the social world.

It is within this social interaction that cultural meanings are shared within the group and then internalised by the individuals. Novak's human constructivism also rejects the view that knowledge is a product that can be faithfully conveyed by teachers. Knowledge is an idiosyncratic, dynamic construction of students. Teachers are negotiators in the meaning-making process. Negotiation does not mean coming to terms or compromise; it means constructing heuristically powerful explanations. All constructivists agree that in the process of knowledge construction, learner is the main actor. New learning depends on learner's previous knowledge.

When individuals encounter new information, they use their own prior knowledge and personal experience to make sense of the new material. During meaning making process, individuals reformulate the new information, restructure their existing knowledge and reorganise their prior conceptual schemes. Learning is thus not a passive receptive process but is instead an active meaning-making process. Constructivist teaching considers student as an active learner and teacher as a guide in the learning process.

In traditional methods focus is on teaching strategies and teacher. Learners are passive receptors of knowledge. In such classrooms, lecture method predominates and teachers stress on completing the voluminous syllabus. In constructivist paradigm teacher facilitates the process of knowledge construction by students.

Constructivism allows academic freedom to students and encourages cooperative learning and sharing of thinking among peers. Students use problem solving method, investigative projects, experiential learning, concept mapping and field surveys for constructing new ideas. In the process, they question the existing ideas, formulate and test hypotheses, draw conclusions, compare their findings and results with those of others, verify and validate their own beliefs. Students develop the habit of self directed learning.

2.6 Learner Centred Approaches

In the traditional classroom where teacher is the main actor and students are passive receptors of knowledge, teacher predominantly uses the lecture method or at best demonstrates and provides explanations to the students. In learner centred approaches, the focus is on the learner and therefore in a learner centred classroom, students use their own learning strategies. They may use problem solving, experiential learning, investigatory approach, social inquiry and concept mapping for constructing and validating new ideas.

2.6.1 *Experiential Learning*

Experiential learning asserts the importance of critical reflection in learning. Kolb, one of the proponents of experiential learning, developed a cyclic model of experiential learning involving four steps, namely concrete experience, observation and reflection, formation of new concepts/ideas and validating new ideas.

Constructivists believe that learners construct new knowledge using their prior knowledge in the particular context in which the cognising individual is operating. Learners are active participants in the construction of knowledge. Learning is thus not a passive receptive process and knowledge cannot be transmitted to passive learners. Learning is an active meaning-making process where learners reformulate the new information, restructure their existing knowledge and reorganise their prior conceptual schemes.

Learner centred approaches stress the importance of enquiry, observation, action, investigation, formulating hypothesis and evaluating new ideas and theories. The methods that can be used in a learner centred classroom include experiential learning, problem solving, investigative projects, concept mapping, field survey and research, creative writing etc. Learner centred classes have scope for divergent learning styles. In order to effectively use these approaches, teachers must understand the learners, their prior experiences, learning disposition, context and culture. Learner centred methods cannot be grafted on traditional methods and require a change in the classroom culture.

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3

Experiential Learning

3.1 Rationale

By the 1980s, constructivism had made a profound influence on the conceptualisation of learning and the way teaching needs to be organised. Further advancement in the field occurred when authors such as Mezirow, Freire and others stressed that the way we process experience are central to any conception of learning. They spoke of learning as a cycle that begins with experience, continues with reflection and later leads to action, which itself becomes a concrete experience for reflection (Rogers,1996). The importance of experience in learning was acknowledged by more and more psychologists.

Experiential learning is not just 'field work' or 'praxis', which means connecting of learning to real life situation. On the contrary, it is a theory that defines the cognitive processes of learning and it asserts the importance of critical reflection in learning. The teaching learning method based on this theory helps in developing four kinds of abilities, namely, concrete experiences, reflective observations, abstract conceptualisation and active experimentation. Experiential learning allows scope for diverse individual learning styles.

3.1.1 Objectives

After reading through this unit you would be able to:

- understand the antecedents to constructivism and experiential learning;
- understand the concept and scope of experiential learning;
- know the recent developments in the experiential learning theory;
- list the learning styles and their characteristics in the context of experiential learning; and

- understand the implications of experiential learning in teaching and teacher education.

3.2 Background

Teaching and learning are interdependent processes. As a teacher, you are as much concerned about learning among school age children, as you are concerned about organising teaching. Our understanding of learning was made possible by the works of psychologists.

The earliest explanations of learning in the organised discipline of psychology were made by those psychologists who are referred to as behaviourists. Main among them were Pavlov, Watson, Hull and Thorndike. Their explanations of learning dominated the field till the 1950s.

According to the behaviourists, learning occurred as a 'response' to certain definite and identifiable 'stimuli' in one's environment. Since it is not possible to observe what is happening inside a learner's brain, they thought that the efforts in measuring and theorising about learning must be limited to merely what is going in - the stimulus – and, what is coming out – the response. By the middle of the twentieth century, the S-R view of learning had emerged as the most accepted explanation of learning in the field of psychology. By virtue of its predominance, the S-R explanation of learning had influenced allied disciplines such as education, linguistics and sociology. Its influence in the field of education was further strengthened by the works of Skinner and Crowder who translated the theory into systematic procedures of organising learning which they called *Programmed Learning* and which could be applied as such by the teachers.

Such a view of learning was too simplistic considering the fact that learning itself is of different types.

3.3 Emergence of Different Views of Learning

The simplistic and reductionist view of learning was challenged first by a set of psychologists called gestaltists and subsequently by those who are known as constructivists. As a result, the reductionist view of the behaviourists was displaced by far more complex non-reductionist views in the 1960s and 1970s. It occurred in psychology through the work of Piaget, Gagne and Bruner, to mention a few. In recent years, constructivism has received considerable attention in education as opined by

Richardson (1997). It has been heralded as a more natural, relevant, productive and empowering framework for incorporation in educational practice.

3.4 Constructivist View

Since constructivism has attained much significance in the field of education, an understanding of it is essential for a teacher. Constructivism is viewed as a meaning-making theory that offers an explanation of the nature of knowledge and of how human beings learn.

According to this explanation of learning, "individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe and the ideas, events, and activities with which they come in contact" (Richardson, 1997). Knowledge, as viewed here, is acquired through an involvement with content rather than initiation or repetition (Kroll & Laboskey,1996).

Learning activities in constructivist settings are characterised by active engagement, inquiry, problem solving and engagement with others. Accordingly, a teacher's role in such settings are not merely that of a dispenser of knowledge. The teacher here is a guide, facilitator and co-explorer who encourages learners to question, challenge and formulate their own ideas, opinions and conclusions. Hence, a teacher who follows the constructivist views on learning will not look for 'correct answers' and will de-emphasise single interpretations.

In conclusion, we may state the following with respect to the differences between the behaviourists and constructivists in so far as learning is concerned.

Behaviourism, as Freire considers, follows a 'banking' model in which the teacher fills students with deposits of information considered by the teacher as true knowledge and the students are required to retain this till such time as needed. Hence, a teacher employing behaviourism follows didactic, memory-oriented transmission strategy. The difficulty with such a strategy is that knowledge acquired is not well integrated with prior-knowledge and is often accessed and articulated only for formal academic occasions such as examinations. Constructivist approaches, in contrast, are regarded as producing greater internalisation and deeper understanding than traditional methods.

3.5 Kolb's Theory Of Experiential Learning

As observed by Stephan Brookfield (1983), the term 'experiential learning' is used with two connotations. On the one hand it is used to describe the learning where a student acquires and applies knowledge, skills and feelings in an immediate and relevant setting. It thus involves a 'direct encounter with the phenomena being studied rather than merely thinking about the encounter, or only considering the possibility of doing something about it' (Borzak, 1981).

The second connotation of experiential learning is 'education that occurs as a direct participation in the events of life' (Houle, 1980). Unlike in the first connotation, learning here is not sponsored by some formal educational institution but is undertaken by people themselves. It is learning that is achieved through reflection upon everyday experiences and is the way that most of us do our learning.

The central reference point for discussion on experiential learning comes from the work of David A Kolb and his associate Roger Fry (1975). Their conceptualisation of experiential learning is presented below.

Kolb developed the model of experiential learning on the basis of the work of Lewin. Lewin's research discovered that learning is best facilitated when there is conflict between a learner's immediate concrete experience and a detached analysis of it by the individual. His cycle of action, reflection, generalisation and testing is characteristic of experiential learning.

Kolb's model, called 'experiential learning cycle', as shown in the Figure 3.1 consists of four elements, namely, concrete

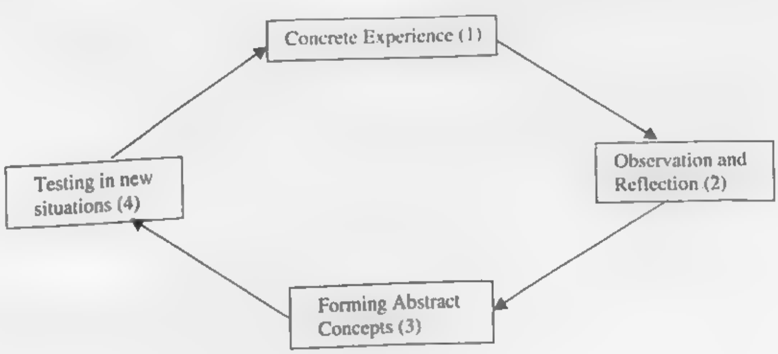

Figure 3.1

experience, observation and reflection, the formation of abstract concepts and testing in new situations.

According to Kolb and Fry (1975) the learning cycle can begin at any one of the four points mentioned above, though the cycle should be approached as a continuous spiral. In reality, however, the process of learning begins with a person carrying out a particular action and then seeing the effect of that action in the situation.

From this first step, the learner proceeds to the second step in the particular situation. This second step has the intention, on the part of the learner, to anticipate what would follow from the action if the same action were to be taken under same or similar circumstances.

Based on this second step, a learner would proceed to the third step of understanding the general principle under which the particular instance falls. The meaning with which the term understanding the general principle is used by Kolb is akin to that of Corman (1976), which reads as follows.

> Generalising may involve actions over a range of circumstances to gain experience beyond the particular instance and suggest the general principle. Understanding the general principle does not imply, in this sequence, an ability to express the principle in a symbolic medium, that is, the ability to put it into words. It implies only the ability to see a connection between the actions and effects over a range of circumstances.

Learning which has occurred in this way may result in formation or strengthening of various rules of thumb or generalisations about what to do in different situations. The learner will be able to decide what action to take in a situation but may not be able to verbalise his actions in psychodynamic or sociological terms. There may thus be difficulty in transferability of his learning to other settings and situations. Equipped with an understanding of the general principle, the learner proceeds to the last step of the cycle, of its application through action in a new circumstance within the range of generalisation.

Two aspects stand out in Kolb's explanation of experiential learning. One, the use of concrete or 'here-and-now' experience to test ideas and two, the use of feedback to change practices and theories.

3.6 Further Developments in Experiential Learning Theory – The Work of Peter Jarvis

Peter Jarvis (1987, 1995), starting with Kolb's model, evolved quite an elaborate model to show that there are a number of responses to the potential learning situation. For developing his model, Jarvis used the method of consultation with adult groups whom he asked to explore Kolb's model based on their own experience of learning. Thus he was able to develop a model, which allowed different routes taken by learners in an experiential learning situation. Depending upon the route taken by a learner, the end product is either non-learning, or non-reflective learning. This could be better understood by a study of the trajectories on the diagram produced by Jarvis.

Non-learning

The trajectory indicated in boxes 1 to 4 of Figure 3.2 is indicative of non-learning. This is a potential learning situation or responds through patterned behaviours only, such as, saying 'hello'.

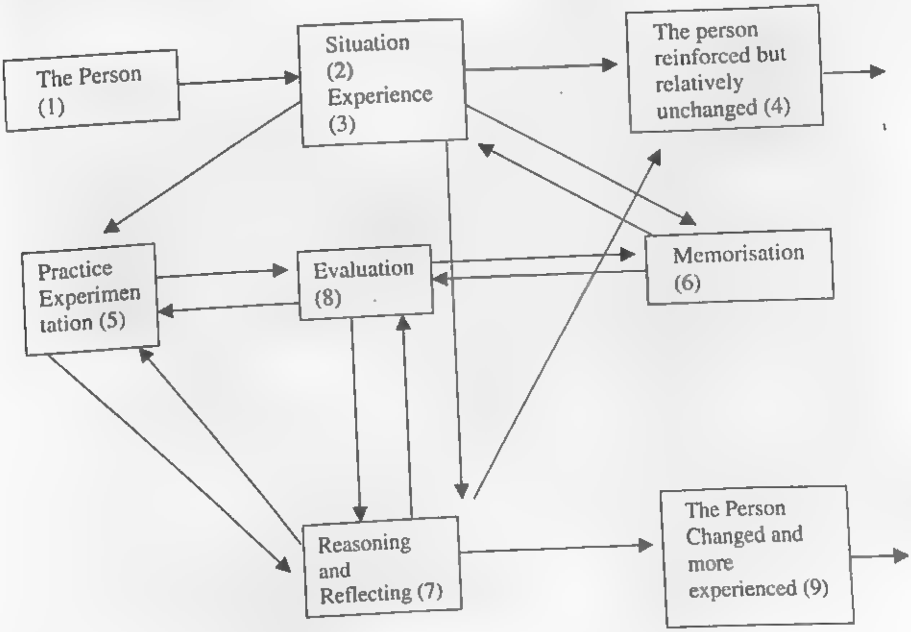

Figure 3.2

Non-reflective learning

Non-reflective learning occurs in more than one way. Several experiences in daily life are not really thought about and are ones where practice is not involved (boxes 1-3 to 6 to either 4 or 9). Acquisition of manual and physical skills, as evident in a training situation, where reflection is not necessarily involved, is an instance of non-reflective learning. Memorisation is another instance of non-reflective learning (boxes 1-3 to 6 to 8 to 6 to either 4 or 9).

Reflective learning

Just as in the case of non-reflective learning, there are several ways in which reflective learning occurs in people. 'Contemplation' is when one considers an experience and makes intellectual decisions about it (boxes 1 to 3 to 7 to 8 to 6 to 9). 'Reflective practice' occurs when a person makes reflection on and in action (boxes 1-3 to 7 to 5 to 6 to 9). Lastly, 'experiential learning', according to Jarvis, refers to the way in which pragmatic knowledge may be learned (boxes 1-3 to 7 to 5 to 7 to 8 to 6 to 9).

3.7 Abilities and Learning Styles in Experiential Learning

Based on the four elements of his model, as discussed earlier, Kolb argues that effective learning entails the possession of four different abilities. They are concrete experience abilities, reflective observation abilities, abstract conceptualisation abilities and active experimentation abilities. These four abilities manifest in four basic learning styles involving learning characteristics on two different continua of learning viz., concrete experience to abstract conceptualisation and active experimentation to reflective observation.

The four basic learning styles are that of converger, diverger, assimilator and accommodator.

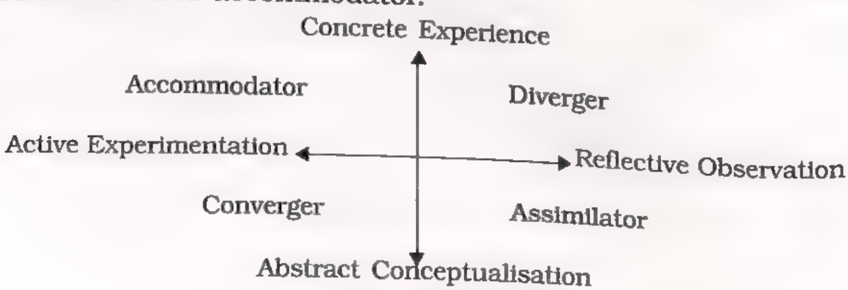

Figure 3.3

Tennant (1996) presents a description of these four learning styles as given in the table below:

Table 3.1

Learning Style	*Learning Characteristic*	*Description*
Converger	Abstract conceptualisation and active experimentation	• Strong in practical application of ideas • Can focus on hypo-deductive reasoning on specific problems • Unemotional • Has narrow interests
Diverger	Concrete experience and reflective observation	• Strong in imaginative ability • Good at generating ideas and seeing things from different perspectives • Interested in people • Broad cultural interests
Assimilator	Abstract conceptualisation and reflective observation	• Strong ability to create theoretical models • Excels in inductive reasoning • Concerned with abstract concepts rather than people
Accommodator	Concrete experience and active experimentation	• Greatest strength in doing things. • More of a risk taker • Performs well when required to react to immediate circumstances • Solves problems intuitively.

3.8 Applications in Classroom Teaching

Constructivism in general and experiential learning in particular presents to teachers and teacher educators the formidable task of translating a learning theory into a theory of teaching (Mac Kinnon & Scarff-Seatfer, 1997). This, in turn, raises questions about what teachers need to know and be able to do.

As discussed in the earlier sections, the learners have their preferred learning styles. Understanding one's learning style helps in understanding one's strengths and weaknesses in experiencing a learning situation. If knowledge of weakness guides us to acquire proficiency in other modes, the knowledge of strengths would have direct learning on areas such as selecting one's career. According to Knox (1986), such a knowledge helps one to make transitions to higher levels of personal and cognitive functioning.

As far as a classroom teacher is concerned, knowledge of the diversity in learning styles in a classroom enables selection or development of learning material that best fits the diversity of the classroom. The very idea of experiential learning directs our attention to the importance of experience in learning and guards against limiting teaching to a mere presentation of information and facts.

A teacher who understands experiential learning would not overlook needs of the student to reflect upon experiences. Brookfield (1990) points out the importance of 'praxis' wherein opportunities for the interplay of action and reflection are ensured. Praxis means that curricula are not studied in some kind of artificial isolation but that ideas, skills and insights learned in a classroom are tested and experienced in real life. Essential to praxis is the opportunity to reflect on experience.

3.9 Illustrations from Curricular Subjects

Following illustrations explain that experiential learning method can be used across the curriculum.

3.9.1 Science

Students in their day to day life do a number of activities where sound is produced. For example, students play musical instruments of different types. Some of them might have played the highest and lowest note of a particular instrument. Students might think of how the sounds of different pitches and loudness

are produced in each instrument. In order to understand and find answer to their observations, students may do concrete activities of the type given below.

Activity 1 : Take an empty coca cola/pepsi bottle made of glass. Blow across the top of the bottle. Does it make a sound? Add some water to the bottle and try again. Add more water and try again. In what way does the pitch change as you add more water?

Activity 2 : Take an empty can. Run a string through a small hole in the can. You may also use a strong cardboard box. Tie a button at the end of the string to prevent it from coming out through the hole. Rub rosin on the string to make the string rough. You may use some other material also. Sit on a chair and hold the box between your feet. Grasp the free and of the string in your left hand. Run a match stick or iron nail up the string quickly and firmly. Does the pitch depend on the size of the box or something else?

Students might observe that in the *bansuri*, air is set into vibration by the lips. The player opens and closes different holes on the wooden tube. The length of the tube is modified by opening and closing different holes and this changes the pitch. In the bottle activity also the pitch changes as more water is added. Students will form their own concepts and validate these against the existing theories.

3.9.2 Mathematics

Example 1

Students might have experienced that many a times when they visit a ration shop, they find that sugar is out of stock or kerosene is out of stock. This situation can happen with all kinds of things – electronic goods, petroleum products, vehicles and so on. Students may reflect as to why shops do not always have a full stock of goods and how stock planning can be done. As a group, they may also develop a model for stock keeping. This exercise would help them in starting their own business or vocation when they enter working life. For stock planning and control, they may first think about the factors necessary in planning. These can be (a) demand for the goods, (b) the value (cost) of goods kept in stock, (c) costs incurred in keeping the stock (d) economising the costs.

(a) Determining demand for the goods

For some goods, the demand may vary from month to month but for some goods like electronic items, the demand may not vary on monthly or seasonal basis and can be assumed to be constant. With the assumption of constant demand, it is possible to drawn a graph of stock level against time. Let, the stock (no. of items) be S in the beginning at t = 0. Since the demand is constant, the stock will be depleted steadily, resulting in a straight line meeting the time axis at t_1. The stock is zero at t_1 time and order is placed again for S items. The stock will finish at time t_2. This way the cycle is repeated and you get a graph as shown here.

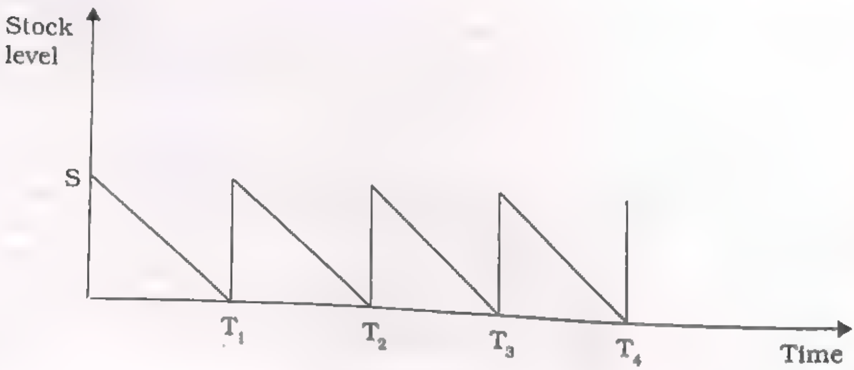

Figure 3.4

Suppose stock is ordered n times in a year and each time S number of items are ordered, then total number of items stocked in one year will be ns. Let ns = D or n = D/S (1)

(where D is the total no. of items ordered in one year)

Time between orders will be 1/n year. If four orders are placed in a year, then time between orders is 1/4 year or 3 months.

(a) Value (cost) of goods kept in stock
Suppose the value of an item (say TV set) is Rs. x
Maximum number of items in stock at a time = S
Minimum number of items in stock at any time = 0.
The stock varies from 0 to S and the average stock at any time is ½ Sx.

(b) Other costs in keeping the stock
i) Order cost

Each time an order is placed, some expenditure is incurred in placing the order, transport and administrative works. If n orders are placed in a year and expenditure incurred each time is Rs.y then ordering cost per year is,

Rs. xy = Dy/S (2)
(taking from (1), n = D/S)

ii) Loss of interest

The money blocked in stock could have been invested elsewhere earning interest, say term deposit scheme. This loss of interest is also counted towards expenditure. If the rate of interest is z% p.a. and the average value of stock is Rs.1/2Sx, then the interest loss in 1 year would be Rs.1/2 Sx X z/100. (3)

Adding (2) and (3), the total expenditure would be,
C=Dy/S + Sxz/200
Next, students may validate their model.

Example 2 :

A student wants to buy a bicycle. He goes to the shop and selects a bicycle of his choice. The cost of bicycle is Rs. 1800, but he has only Rs. 600 in hand. The shopkeeper offers hom a scheme – he can pay Rs. 600 now followed by two monthly instalments of Rs. 610 each. The student considers how much interest he has to pay and whether he should accept the offer or not.

(a) Determining the interest charged under the scheme

Price of bicycle	= Rs. 1800
Cash in hand	= Rs. 600
Balance amount to be paid	= Rs. 1800 – Rs. 600
	= Rs. 1200

This amount of Rs. 1200 has to be paid in two instalments with interest.

Amount of each instalment	= Rs. 610	
Amount to be paid in two instalments	= Rs. 1220	
Interest to be paid	= Rs. 20	...... (1)
Principle amount for the first month	= Rs. 1200	
Principle amount for the second month	= Rs. 1200 – Rs. 610	
	= Rs. 590	

Total principle amount = Rs. 1790
Interest = $(1790 \times r \times 1) + (100 \times 12)$ ...... (2)
where r is the rate of interest.
Equating (1) and (2),

$(1790 \times r \times 1) + (100 \times 12) = 20$
$r = (20 \times 100 \times 12) + 1790 = 13.41\%$ approximately.

3.9.3 English

Students can first do this activity. Read the passage through once. Then fill in the blanks with any word which best fits the blank.

In the Kingdom of Fools

In the kingdom of Fools, both the king and the minister were idiots. They did not want to run.........like other kings, so they.......to change night into day and day into night. They.........that everyone should be awake at......, and ....to bed as soon as.............sun came up. Anyone who............would be punished with death. The king and the......were delighted.........the success of their project. One day a guru and his.........arrived in the city. It was.........beautiful city, it was day time, but there was no......... about. Everyone was ...., not a mouse stirring. Even the cattle.........been taught to sleep ....day. The two strangers were amazed what they saw around them and wandered around town till evening, when suddenly the whole town woke up and went about its mightly business.

After doing this fill-in-the-blanks activity, students will again read the passage and make sense out of it. They may again replace some of these words and read the whole passage again.

3.10 Summary

Experiential learning, as far as its central idea is concerned, is not totally new. But it suggests a renewed look at the way teaching and learning get organised in our classrooms. It suggests that the learner and not the teacher must occupy the centre stage of classroom activity. The approaches which engage students in interdisciplinary exploration, collaborative activity and field based opportunities for experiential learning, reflection and self-examination are used more and more by the teachers.

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4

Concept Mapping

4.1 Rationale

In order to improve instructional methods carried out in the classroom and improve students' learning, there have always been search for more potential ways of instruction. 'Concept mapping' has evolved as a useful strategy for leading students towards meaningful learning. Concept mapping requires students to structure their ideas/conceptual understanding, indicating the inter-relatedness of concepts. Concept mapping is basically a learner's activity and helps learners in examining their own understanding of concepts and in reformulating their concepts. Concept mapping can be used to develop a lesson, summarise a lesson and also to evaluate pupil learning.

This chapter discusses the psychological basis of this strategy, how concept mapping facilitates meaningful learning, steps involved and the use of concept maps with illustrations from different curricular subjects. The understanding of concept mapping as an instructional strategy will help teachers in using this strategy in the classroom for effective curriculum transaction.

4.1.1 Objectives

After reading this chapter, you will be able to :

- develop an understanding of concept mapping as an effective instructional strategy which can be used to teach any subject.
- develop an ability to draw concept maps and to make students develop concept maps on their own.

4.2 Introduction

Concept map is a device for representing the conceptual structure of a subject/discipline in a two-dimensional form which is analogous to a road map. A concept, as defined by Novak, is

regularity in objects or events designated by a specific label. Concept maps are diagrammatic representations which show meaningful relationships between concepts in the form of propositions.

Propositions are two or more concept labels linked by words which provide information on relationships or describe connections between concepts.

Concepts are generally isolated by circles and connected by lines. Lines are labeled with 'lining words' which describe how the connected concepts are related to each other. Two connected concepts make up a 'prepositional linkage' or a statement about how some piece of the world looks or works.

Concepts are arranged hierarchically, i.e., the most general concept (superordinate) is found at the top of the map and lower concepts (subordinate) are less inclusive than higher ones. 'Cross links' are prepositional linkages that connect different segments of the concepts hierarchy. They may indicate syntheses of related concepts, a new interpretation of old ideas and some degree of creative thinking.

Concept mapping is seen as a useful strategy for helping students learn about the structure of knowledge and the process of knowledge production. Learning about the nature and structure of knowledge helps students to understand how they learn. Knowledge about learning helps to show them how humans construct new knowledge. In contrast to students who learn by rote, students who employ meaningful learning are expected to retain knowledge over an extensive time span and find new related learning progressively easier.

Concept maps use three types of knowledge: facts, concepts and generalisation. It is a learning strategy that was developed first as a research tool to represent learner's prior relevant knowledge and later as a tool to enhance meaningful learning.

4.3 Psychological Basis of Concept Mapping

The use of concept maps as a teaching strategy was first developed by J.D.Novak of Cornell University in the early 1980s. It was derived from Ausubel's learning theory which places central emphasis on the influence of students' prior knowledge on subsequent meaningful learning. According to Ausubel,

> 'The most important single factor influencing learning is what the learner already knows. Meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts they already possess.

Ausubel suggests that when meaningful learning occurs, it produces a series of changes within our entire cognitive structure, modifying existing concepts and forming new linkages between concepts. This is how meaningful learning becomes lasting and powerful while rote learning is easily forgotten and not easily applied in new learning or problem solving situations.

Taking additional ideas from Ausubel's theory that cognitive structure is organised hierarchically and that most new learning occurs through derivative or correlative subsumption of new concept meaning under existing concept/propositional ideas, Novak developed the idea of hierarchical representation of concept/propositional frameworks called 'cognitive maps' or 'concept maps' (Novak, 1979,1980,1981).

Novak and Symington (1982), found that concept maps were not only a useful tool to represent changes in the knowledge structure of students over time, but also helped them to 'learn how to learn'. They found that concept maps were useful representing knowledge in any discipline and aided in organising and understanding new subject matter. Concept mapping has become an important tool to help students learn to learn meaningfully and to help teachers become more effective teachers. Concept maps are useful in helping students to recognize and modify faulty knowledge structures (Novak and Gowin,1989).

4.4 How does Concept Mapping Facilitate Meaningful Learning?

First, concepts are not isolated, but rather connected together, showing inter-relationships. Cross-links are particular powerful connections, which form a 'web' of relevant concepts, probably enhancing their anchorage and stability in cognitive structure. They not only connect general concepts to specific concepts, but also tend to connect different sub-domains of conceptual structure. Linkages that are made only vertically would be likely to be forgotten than those that are also made laterally since vertical linkages are somewhat more specific instances of concepts whereas cross links relate together concepts in different domains of a concept.

Concept mapping demands clarity of meaning and integration of crucial details. The process of constructing a concept map requires one to think in multiple directions and to switch back and forth between different levels of abstraction. In attempting to identify the key and associated concepts of a particular topic or sub-topic, one will usually acquire a deeper understanding of the topic and clarification of any prior misconceptions.

4.5 Steps Involved in Concept Mapping

The steps followed in constructing the concept maps are as follows:

(i) The students are given the material pertaining to the lesson/unit and given instructions to read the material and select the key concepts. The concepts are listed on the blackboard as they are identified. Discussion is held with the students as to which concept is more important and most inclusive in the lesson/unit.

(ii) The most inclusive or superordinate concept is placed at the top. The most general and inclusive concepts are listed next, working through the first list until all concepts are rank ordered.

(iii) Students are asked to help in choosing good linking words to form the propositions shown by the lines on the map.

(iv) Cross links between concepts in one section of the map and concepts in another part of the concept tree are made with the help of students. The concepts are either circles or put in small boxes.

(v) Maps are reconstructed if they have poor symmetry or are poorly clustered.

Since concept mapping is a relatively new strategy, initially teachers must provide guidance to the students for developing their concept maps. The teachers may draw concept maps on the black board with the help of students. Thereafter, students may draw concept maps on their own. The concept maps may be evaluated by students themselves and also by the peers.

For different learning segments, the superordinate – subordinate relationships of concepts will change (Ref. Figures 4.2 and 4.3). Novak uses the analogy of a rubber sheet for this in which almost any concept on the map can be 'lifted up' to the superordinate positions, but still retains a meaningful prepositional relationship with the other concepts on the map.

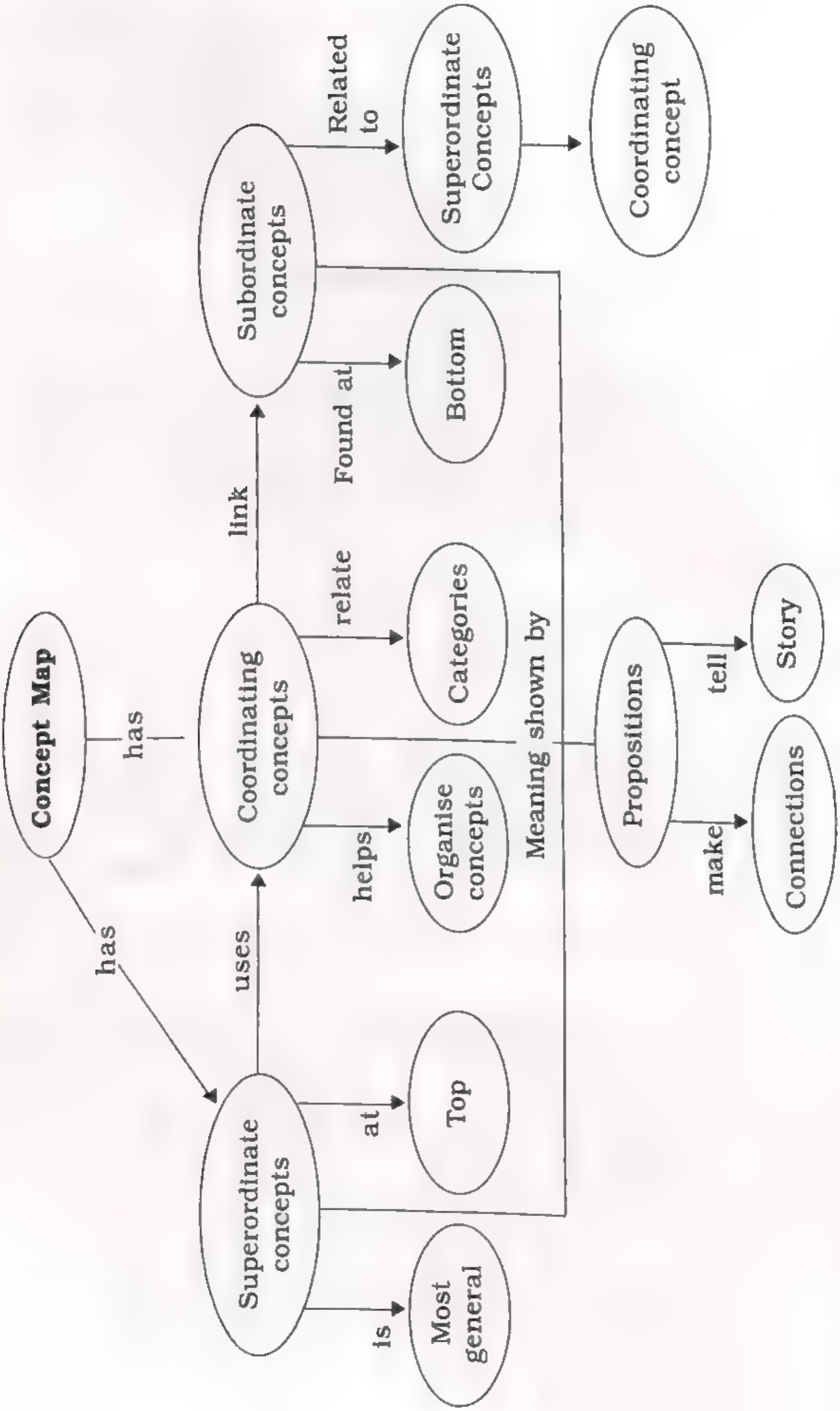


Figure 4.1: Concept Map for concept maps

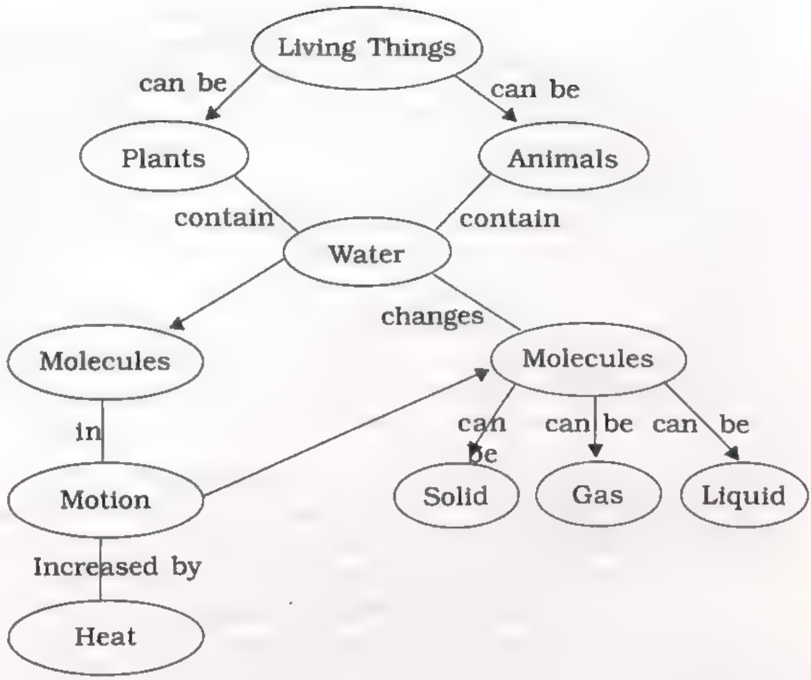


Figure 4.2: Example (1) of a Concept Map

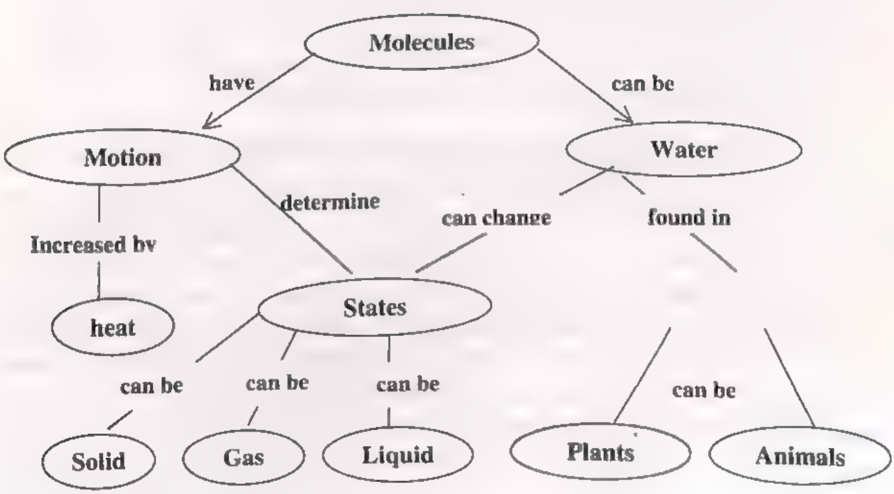


Figure 4.3: Example (2) of a Concept Map

One big advantage of using concept mapping is that it provides a visual image of the concepts under study in a tangible form that can be focused very easily. During the formulation process it consolidates a concrete and precise understanding of the meanings and inter relations of concepts, thus resulting in an active process of learning.

Concept mapping helps students achieve high-quality and meaningful learning outcomes. As discussed earlier, meaningful learning implies that, as a result of instruction, individuals are able to relate new material to previously acquired learning. If connections with the earlier knowledge are missing, learners may regard the ideas they are taught as useless abstractions that only need to be memorised.

As an example, learning that electricity flows through a circuit can be meaningful for children if they are able to see with the guidaance of a teacher that this idea applies to their previous understanding about how and where electricity is used. Children may have previously believed that electricity comes from the wall where an electric switch or outlet is located. When someone turns the switch on or plugs an appliance into the outlet, electricity flows to a lamp or an appliance. A teacher can facilitate learning by helping children understand that electricity indeed flows through the switch or comes out of the outlet, but also that there are continuous electric wires between the electric pole outside the house and the switch and between the switch and the appliance (Science for all children, 1998).

4.5.1 Concept Mapping to Teach Curricular Subjects

As stated earlier, educators have always been in search of more potential ways of instruction to help students learn effectively. In recent years, educators have suggested various directions for the improvement of teaching and learning. Beginning with demonstrations, enquiry, discovery method and problem solving techniques, science educators have suggested constructivism in the classrooms as an interpretative process involving individual's constructions of meanings related to specific occurrences and phenomena. New constructions are built through their relations to prior knowledge and it is a pedagogic challenge for the teacher to focus on students' learning with understanding.

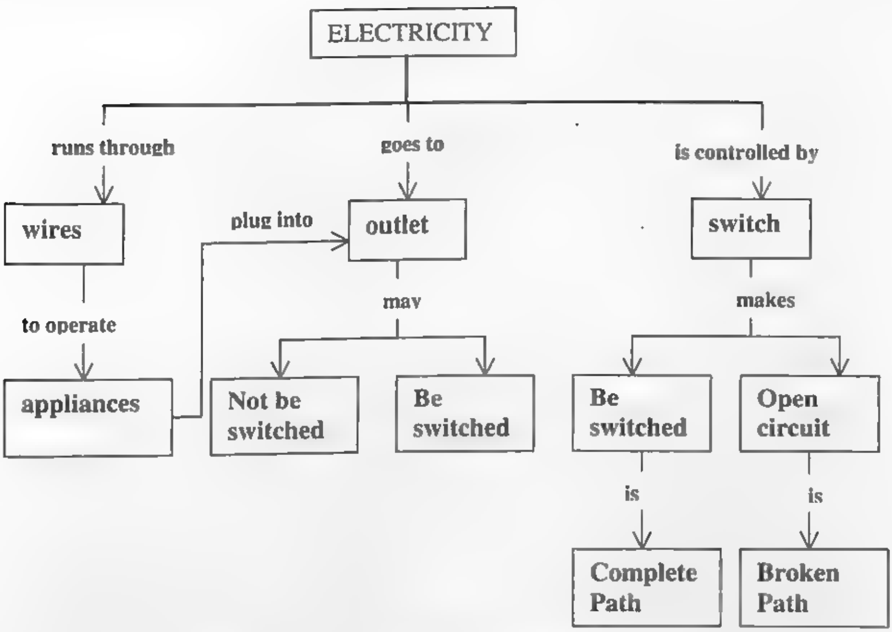


Figure 4.4: Concept Map of Electricity

To learn, for example, science, from a constructivism philosophy implies direct experience with science as a process of knowledge generation in which prior knowledge is elaborated and changed on the basis of fresh meaning negotiated with peers and teacher. Concept mapping stimulates this process by making it explicit. It was considered as an ideal tool to see relationships between concepts and to develop an enquiring mind and other process skills in students.

In order to develop the attitude and understanding of concepts teachers need to recognise the relation between the manners by which students initially experience and process information and their subsequent ability to retrieve and transfer that knowledge to novel situations (Minstrell, 1989).

Teachers who view and present science as a list of terms rather than as a concept mapping process perpetuate science classroom learning environment which fosters negative attitudes and alienates most students. It is important for teachers to realise that -

i) Concepts in many subjects like science and mathematics are interrelated and hierarchical.
ii) Concepts can be developed from a variety of perspectives, as long as the relationships among concepts are accurate.

iii) Concept maps can be used to identify prior knowledge and misconceptions in both teachers and students.
iv) Students' explanation of the concept map reveals the difference between learning concepts and memorising terms.
v) Individuals have different learning styles and interests.
vi) Meaningful learning can be achieved by networks of information.
vii) Students need to learn how to question and engage in meaningful learning.

4.6 Use of Concept Maps

In constructing concept maps, difficult concepts can be clarified and they can be arranged in a systematic order. Using concept maps in teaching helps teachers to be more aware of the key concepts and relationships among them. It helps in deciding what to include in a curricular unit or lesson plan. Taking time to identify concepts yields clarity about topics and helps to determine which topics are worth learning. Mapping concepts suggest specific objectives that teachers must plan for pupils. It also helps to seek the breadth and depth of a topic, see logic of relationships and choose proper activities and teaching aids. This understanding improves teachers' planning and instruction.

Since knowledge is vast, and most of the teachers have acquired it in pieces at different stages, there is a possibility of not seeing important connections between different ideas. As an exercise, concept mapping provides an opportunity to express one's understanding about various concepts and to show relationships with other similar and dissimilar concepts.

There is evidence that concept maps can help teachers become more effective (Beyerkach and Smith, 1990; Hozetal, 1990) and can serve as a heuristic for curriculum development (Starr and Krajicik, 1990). They are essential tools for planning and teaching and can help improve students' concept constructions.

Concept mapping is a more recent development that is widely used as a constructivist learning model. It has been used as an advance organiser to focus pupils' attention and guide them along to seeing the bigger picture and for use as a mental scaffolding for organising their thoughts and discoveries.

Concept mapping can be used for several purposes like (a) to generate ideas (brain storming); (b) to design complex

structures (long texts, hyper media, large web sites); (c) to communicate complex ideas; (d) to aid learning by explicitly integrating new and old learning; and (e) to assess understanding or diagnose misunderstanding of a concept.

By assessing the concept maps developed by the students, the teacher can:

i) gain insight into the way students view a concept or a topic;
ii) examine the valid understandings and misconceptions students hold; and
iii) assess the structural complexity of the relationships students depict.

Apart from assessing the students' understanding of concepts, the teachers can also use concept maps to organise their ideas in preparation for instruction, as a graphic organiser during class and as a way to encourage students to reflect on their own knowledge and to work together and share their understanding in collaborative group settings.

Concept maps can also be used for pupil evaluations. They may be used as formative and summative evaluation tools to see whether pupils have understood the concepts, relationships between concepts and the topic as a whole.

Besides the cognitive abilities that have been stated, concept maps are not the only ways to represent meanings. Flow charts are often used to represent sequences of activities. Organisational charts, cycles such as water cycle in science, semantic networks and predictability trees that are used in some psychological and linguistic writings are some sort of maps. But they are not based on the theory of learning and theory of knowledge that underlie the concept mapping strategies and their application to education.

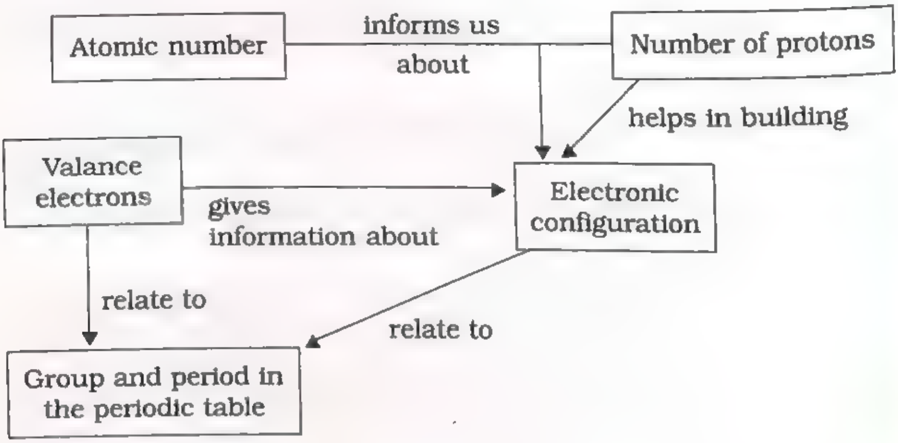
Concept mapping done in groups also develops certain social skills, and values like tolerance, respect for others' views, group spirit, cooperation, discussion abilities, open mindedness and so on.

4.6.1 *Illustrations From Different Curricular Subjects*

The illustrations given in this section suggest that concept mapping as a transactional strategy can be used across the curriculum.

Science: Concept mapping has been increasingly used by science educators and teachers.

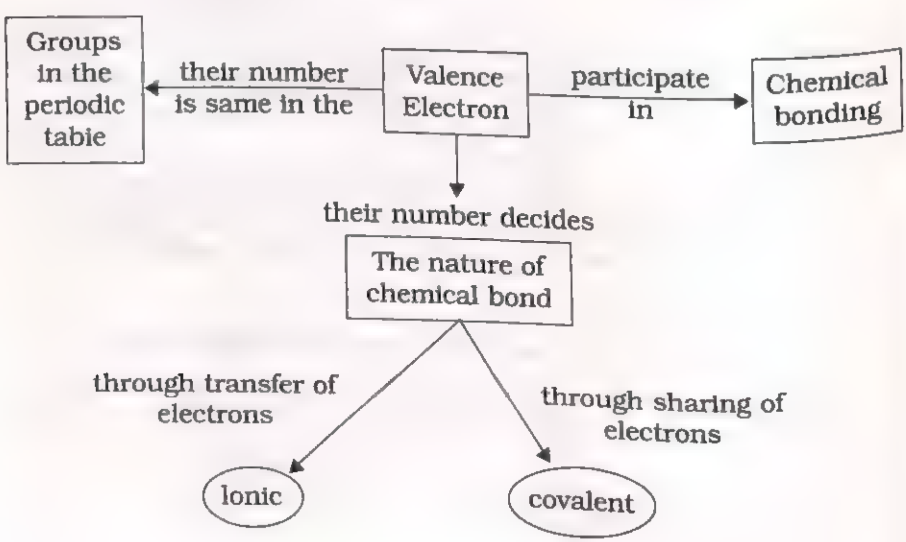
Example 1 : Concept map depicting the relationship of atomic number with valence electrons and significance in the Periodic Table.



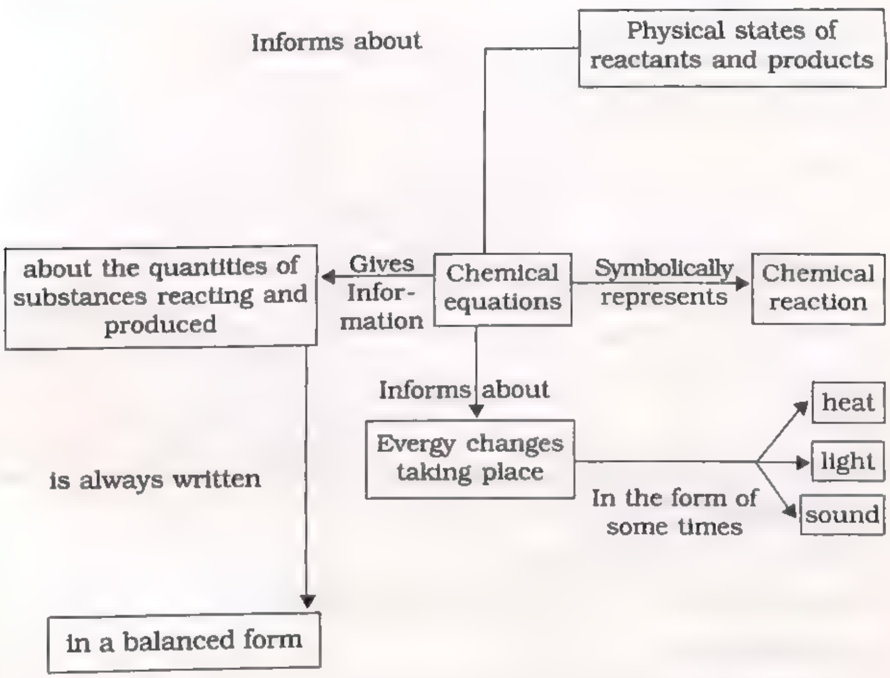
Abilities to be developed

- Seeing relationships, thereby developing analytical thinking skills.
- Deductive reasoning ability.

Example 2 : Concept map showing the role of valence electrons in chemical bonds and also their significance in the Periodic Table.



Example 3 : Concept map showing what a chemical equation represents and informs about.



Abilities developed

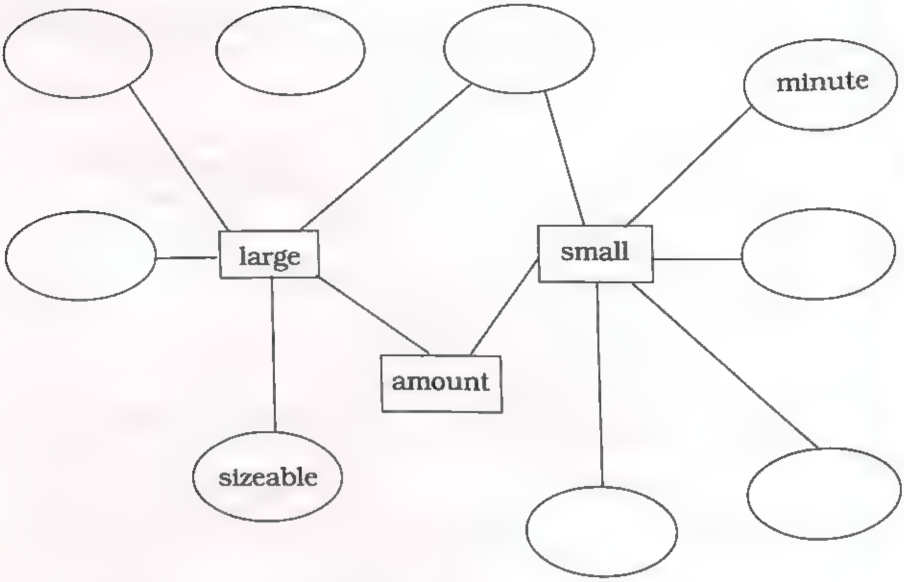
- Forming relationships develops analytical thinking.

English

Example 4 : Teaching Vocabulary

Given below are some adjectives which can combine with amount. Divide them into two groups, small and large and fill in the bubbles. You can look up a dictionary if you do not know the meaning of some words.

Minuscule, gigantic, overwhelming, minute, meager, excessive, insignificant, sizeable,tiring,considerable



(Adapted from *English vocabulary in use* by Michael McCarthy and Felicety O'Dell. CUP)

Method : Individual work

Ability *developed* : looking up a dictionary

4.7 Summary

Concept mapping as a tool of learning and assessment has proved to be an effective instructional strategy through several research studies and projects. Since success is evident in the significant and substantial gains in students' achievement and concept attainment of students, teachers should attempt to use this as a part of their instructional methods in classroom teaching. The purpose behind the use of this strategy should be to provide workable strategies to help students **learn how to learn**.

Teachers can develop activities of the following type to teach students through concept mapping strategies.

(i) Develop a concept map for teaching any topic of your choice and use it in the classroom while teaching.
(ii) Train your students to prepare their own concept maps both individually (on their own) and in groups.
(iii) Use concept mapping strategy at the review stage of your lesson.
(iv) Develop a concept map as a tool of assessment on any topic of your choice.

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5

Problem Solving

5.1 Rationale

Learning encompasses much more than simply acquiring information and developing an understanding of concepts. Higher levels of learning involve transfer and application of the knowledge and understanding to new situations. These higher levels of learning can be achieved through 'problem solving'. The problem solving strategies give students opportunities to think rationally, understand intellectual processes and practise intellectual skills. Learning through problem solving is more meaningful, permanent and transferable compared to learning through expository methods. The problem solving method assumes that students are active participants in the construction of new knowledge rather than passive receivers of knowledge through lectures, demonstrations, textbook reading or recitation.

The problem-solving method has several advantages over expository methods. The active participation and personal involvement of the learner motivate students to learn and contribute to the feeling of self-worth. The process of problem solving requires students to identify and define a problem, select or design possible solutions, test trial solutions, evaluate the solutions and revise or redesign the steps, if required. The role of the teacher in problem solving is that of a guide and facilitator. Teachers must provide students with activities that develop their problem-solving skills.

5.1.1 Objectives

After studying this chapter, you will be able to:

- understand the philosophical assumptions and psychological principles underlying problem-solving method.
- identify thinking skills involved in problem solving.
- describe the steps involved in problem solving.
- design problem solving situations for students.

5.2 Philosophical Underpinning

Problem solving strategies are rooted in John Dewey's philosophy of pragmatism. In recent past, Piaget and Vygotsky presented the constructivist view of knowledge which also emphasizes problem solving strategies for construction of new knowledge. Constructivists believe that knowledge is always the result of a constructivist activity and therefore cannot be transferred to a passive receiver. Problem solving strategies become important when role of the student changes from 'knowledge acquisition' to 'knowledge construction'.

As an exponent of pragmatism, John Dewey maintained that philosophy must be described in terms of the problems with which it deals. These problems arise from the immediate environment of the individual, and philosophy has meaning and significance only when it helps to find solutions to these problems. By successful solution of these problems, human beings can adopt, change and create their environment. John Dewey stated, "It is not the business of the school to transport youth from an environment of activity into one of cramped study of the records of other men's learning but to transport them from an environment of relatively chance activities into one of activities selected with reference to guidance of learning".

It suggests that the role of the school is to replace chance activity by activities that lead to genuine knowledge and fruitful understanding. Activities should not be provided just to glorify the activities theeselves but these should be purposeful. The role of the teacher is to select, organise and direct experiences so that learners participating in the activities gain maximum knowledge and understanding. The teacher must provide students with such opportunities that help them in identifying and solving problems. The problems must be real and relevant to the students.

Dewey's philosophy emphasises the importance of experience, experimentation and learning by doing. The importance of experience and past knowledge is that they help young learners in solving the problems that they now confront. Two things that can be expected to predominate in such a classroom are *"conformity of a reflective atmosphere"*, where students are engaged in thinking through problem solving and *"continuity of a democratic atmosphere"*, required for development of the quality of human relationships.

The more recent philosophy of constructivism offers a viable alternative view of knowledge. Constructivists (Piaget, Vygotsky) believe that knowledge is subjective and learners construct knowledge in the social and cultural environment in which they are embedded. Learners are active participants in the construction of knowledge in individual ways. The instructional strategy based on this belief suggests that students should participate in experiences such as inquiry activities, discovery, problem solving, discussion with peers and teachers, collecting and interpreting information from different sources, expressing their understanding in diverse ways, applying and validating their understanding in new ways and so on.

Constructivist philosophy also has two schools of thought - radical constructivism and social constructivism. Radical constructivists like Piaget believe that learning involves meta-cognition, which reflects on one's learning process. The nature of the learning task is crucial for learning to take place. Social constructivists (Vygotsky) maintain that knowledge must be viable, not only personally, but also in the social contexts in which the actions occur. Thus according to radical constructivists individuals construct knowledge on the basis of their prior knowledge and experiences whereas social constructivists believe that individuals construct knowledge through social interaction and by negotiating with others in particular social context.

Constructivism provides a new theory of teaching and learning. This theory calls for a major shift from teacher centered direct instruction to student centered, understanding based teaching. The role of the student in a constructivist classroom changes from 'knowledge acquisition' to 'knowledge construction' and students work on independent or collaborative projects or problems.

5.3 Psychological Basis of Problem Solving

Psychological research on problem solving was sporadic till about 1960. A few independant psychologists worked in this area but there was no major convincing point of view, theory or technique to bring their work into focus. In 1960, the information processing theory provided by Newell, Simon and Shaw gave some impetus to the researches in the area of problem solving. At about the same time in the 1960s Gagne provided conditions of problem solving in humans, which interested many scientists.

During 1980s and 1990s Piaget and Vygotsky's investigations into the thought processes involved in problem solving further strengthened researches in this area. Today problem solving is an area of much interest to psychologists and scientists. This section discusses how different psychological theories influenced the development of approaches to problem solving.

5.3.1 Behaviorists' Point of View

Stimulus-Response (S-R) theorists and operant behavior analysts believed that problem solving is a kind of discrimination learning. They analysed problem solving in terms of chains of S-R associations and pointed out that some kind of hierarchical organisation of S-R chains is crucial in any adequate theory of verbal behavior. Gestalt psychologists such as Kohler (1925) and Wertheimer (1945) viewed problem solving as a matter of integrating previously learned responses. For them, true problem solving was insightful, that is, the organisation of responses occurred relatively suddenly and this organisation was both enduring and could be generalised, but Gestalt psychology was silent about the structure of insightful organisation.

Behaviorist theories of problem solving were not accepted by researchers as these did not provide adequate account of the complex behavior involved in problem solving. Behaviorists made no efforts to decode or understand what happens between stimulus and response, that is, 'mediating responses' or anything intervening between stimulus and response. However, these theories pointed towards two important factors involved in problem solving—first, the hierarchical organisation of S-R contingencies and second, the role of previous learning in problem solving.

5.3.2 Information Processing Theory

Newell, Simon and Shaw (1958) introduced a new theory of problem solving based on concepts of information processing and computer programming. They believed that humans process information in exactly the same way as computers do and considered this processing of information as the influencing step between inputs and outputs.

The information processing theory states that similar to a computer program where the postulated details of a precise set of mechanisms are described in a formal programming language to account for the observed behavior, the problem solving process

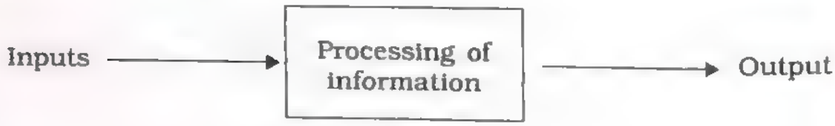


Figure 5.1

consists of what human subjects do in writing/orally /in action under experimental conditions while solving problems and these written/oral activities/action are hierarchically and sequentially organised as in a computer program.

This theory spawned a number of studies in the area of problem solving. The more recent model of information processing emphasises the role of memory in information processing and states that humans construct symbolic representations of the world through information processing. Memory consists of three parts: the short-term memory (sensory buffer), the working memory and the long-term memory.

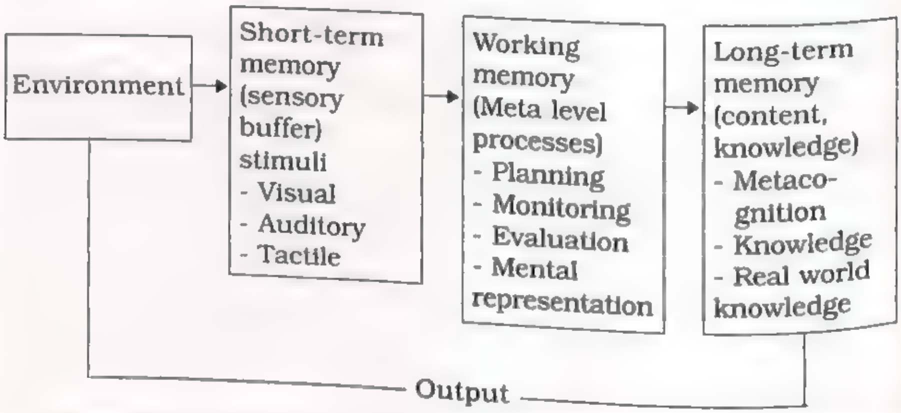


Figure 5.2: *Structure of memory (Source: Muijs Daniel and Reynolds David, 2001)*

An individual experiences the environment through senses which are registered as visual, tactile and auditory stimuli in the sensory buffer (short-term memory). These are then converted into a form in which they can be used in the working and long-term memories. The sensory buffer can register a lot of information but can hold this information only for a short time. Some part of the information in short-term memory is lost and some part is transmitted to working memory.

Thinking takes place in the working memory phase. Working memory receives its content from the short-term memory and long-term memory but has a limited capacity for storing information. Working memory contains the information that is actively being used at any point of time.

Long-term memory consists of nodes which represent chunks in memory and the neural network which represent connections between these chunks or nodes. These nodes can be equated with concepts and links with meaningful associations between concepts. Together these form schemata or cognitive maps. Activating one item of the cluster is likely to activate all of them, that is, by recalling one concept, all related concepts can be recalled. This theory describes the processing of information at the symbolic level. It does not consider analysis at neurological level.

5.3.3 *Gagne's Conditions for Problem Solving*

Gagne's conditions of problem solving suggest a guided discovery method of problem solving. Gagne examined the conditions which may bring about the problem solving behavior. Some of these conditions are external to the learner such as stimuli, verbal directions and instructions whereas some are internal to the learner such as processing of problem solving. To understand the processes of problem solving one must also understand the linkages between external and internal conditions.

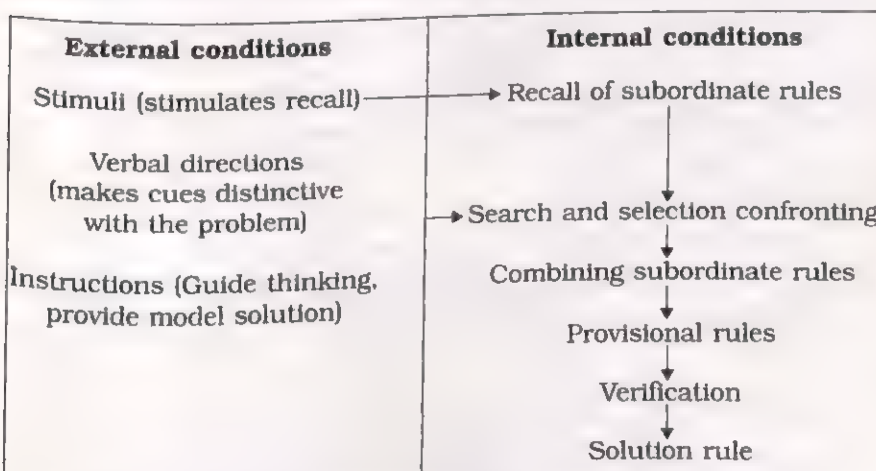


Figure 5.3: ***Linkage between external and internal conditions (Gagne 1965)***

In external conditions, stimuli refers to the physical objects employed in solving a problem such as playing cards in card trick problem, matchsticks in matches pattern problem etc. Gagne believed that in problem solving, coding of these stimuli is required such as interpreting or reacting to numbers in a card trick problem or pattern and number of sticks in matches problem.

In complex problem solving situations, the stimuli can be classes of objects, events or concepts. These factors stimulate the recall of subordinate rules. *Verbal directions* may help the learner in confronting the problem. For example, directions such as "notice the denominator of given fractions in the problem" or "notice the level of water in the beaker" or "look at spots on this card" may provide distinctive clues to the learners and help in distinguishing between relevant and irrelevant clues for problem solving.

Directions are of some importance in bringing about problem solving but these do not convey or represent the content of the problem. *Instructions* as external conditions help in eliciting the mediating processes and stimulate recall of concepts, principles and strategies. Instructions are different from directions in that these represent or point towards content of problem solving whereas directions do not represent the content of problem solving. Instructions point towards relevant features which are helpful in solving the problem.

Instructions give directions to the thinking process and inform the learners about the nature of solution required. For example instructions may urge learners to ignore certain hypothesis about the solution, thus narrowing the process of search for a correct solution. The combining of rules, verification and solution may be guided by instructions.

5.3.4 Piaget's Cognitive Model of Problem Solving

Piaget's theory of cognitive development strongly influenced problem-solving programmes. The Swiss psychologist Jean Piaget suggested that in order to understand how children think we must look at their ability to solve problems. Children use qualitatively different methods of solving problems at different stages of development. As they grow, their thinking changes qualitatively; the tools with which they think change.

According to Piaget there are three main factors which bring about these qualitative changes in thinking. These are

maturation, activity and social transmission. Maturation relates to the unfolding of biological changes that are genetically programmed into us at birth. As the level of maturation increases, the child's ability to act on her/his environment increases. This enhanced activity alters children's thought processes. When children act on their environment, they interact with other peers, teachers, parents etc. and learn from them. This learning through social transmission also depends on the learner's developmental stage.

Piaget described the four stages of cognitive development as sensory-motor stage (0-2 years), pre-operational (2-7 years), concrete operational (7-12 years) and formal operational (12+ years).

During the sensory-motor stage, children learn about the world through sensory information and action. In pre-operational stage, the child develops the ability to understand symbols. The child develops the ability to understand conservation but she/he thinks only in one direction; thinking backwards or reversing the steps of a task is difficult for her/him. At the third stage, the concrete operational, the child develops a logical and systematic way of thinking but she/he is still tied to the physical reality. At this stage, children can solve problems related to classification, seriation and reversibility.

The next stage, formal operational, is not reached by all students. At this stage, the students recognise that a real, actually-experienced situation is only one of several possible situations. Students must be able to generate different possible solutions for a problem by thinking in a systematic way using scientific reasoning. Teachers of secondary stage must help students to get to the formal operational stage.

5.3.5 *Vygotsky's Social Constructivism and Problem Solving*

The Soviet psychologist, Lev Vygotsky believed that, besides maturation, children's interactions with others through language strongly influence their level of conceptual understanding. Vygotsky believed that one can learn from others, both of the same age and of a higher age, and the role of teachers, parents and peers in children's learning comes here.

Adults and peers operate through scaffolding in the *Zone of Proximal Development*. The zone of proximal development refers to the gap between what a person is able to do alone and what

she/he can do with the help of someone more knowledgeable or skilled than herself or himself. Teachers can help bring the child's knowledge to a higher level by intervening in the Zone of Proximal Development by providing children's thoughts with scaffolds. These scaffolds are not needed once the learning process is complete. In problem solving situations Vygotsky sees teachers and peers as living representatives of the culture with whom the learners interact. Teachers are considered the means of transition of the knowledge of a particular culture. Thus, for Vygotsky, problem solving is a cooperative activity.

5.4 Problem Solving as an Instructional Strategy

Problem solving can be used to develop conceptual understanding and the ability to transfer and apply this understanding to new situations. It gives students opportunities to think rationally and to see relationships and disciplinary structures. Through this method students develop intellectual skills of thinking and learn how to learn. Thinking is the basic skill required in problem solving by which students make sense out of experiences. Problem solving requires the ability to identify and describe the problem, suggest and design the possible solutions, test trial solutions, evaluate the outcome and revise these steps where necessary. Thinking skills and steps in problem solving can be taught by providing students with problem situations and opportunities to solve these situations.

5.4.1 Developing Thinking Skills Among Students

Bayer (1987) divides thinking skills into two main categories – cognitive and metacognitive. *Metacognitive skill* refers to knowledge about one's own thought processes and the ability to monitor what one is doing, why one is doing and how what one is doing will help in solving the problem. This allows one to ascertain whether the strategies being used are effective or not and enables strategies to be changed if necessary. Lack of metacognition leads to students using ineffective, inefficient and slow methods of problem solving. Self-regulation and conscious analysis of each step may help students in selecting the appropriate problem solving strategies.

Metacognitive skills help students in analysing their strengths and weaknesses. Metacognitive thinking can be developed with the help of specific activities and through cooperative group work.

Some of the strategies suggested by Schoenfeld (1987) for developing metacognitive thinking are discussed here. These can be tried out in the classroom to see the progress of students on self-regulation and self-monitoring processes and the effect on their problem solving strategies.

(i) Assign specific activity to each student in the cooperative learning situation. Each student working in the group can be given cards containing a number of basic questions that may help them to think about their own thinking such as 'why have I selected this strategy?' 'what can be the other strategy?' 'is this strategy getting me anywhere?' and so on. This will help them to reflect upon their own actions and the strategies that they follow to solve the problems. These cards may be treated as 'scaffolds' and can be removed once students have internalised thinking.

(ii) A group of students may work on a problem with the teacher as the moderator. Students would choose different strategies to solve the problem. Some of these may not turn out well and may not lead to the correct solution. The students must be encouraged to try till they reach the right solution. This may be followed by discussions where students reflect upon the strategies that they followed. This activity has been found to help self regulation.

(iii) Students may be asked to solve a problem on the blackboard or wall board and also present the process and steps followed in problem solving. This leads to reflective thinking on what they have done and why they chose these strategies.

(iv) Students may solve problem in cooperative learning situation. The strategies that students follow to solve a problem may be recorded through video. The unsuccessful or ineffective problem solving strategies selected by them may be shown on video. This can help them to understand what they were doing. This would also impress upon them the importance of awareness of what one is doing.

Cognitive thinking skills required in problem solving include inductive and deductive reasoning, distinguishing between relevant and irrelevant information, recognition and categorisation of problems, analogical reasoning, generalisation and evaluation etc. These skills help learners in identifying the problems, planning possible solutions, test trial of solutions and evaluation of results.

Cognitive thinking skills can be taught directly as well as through teaching of different curricular subjects. A number of programmes aimed at the teaching of thinking skill have been developed and tried out. One such intervention programme based on Piagetian and Vygotskian thinking was tried for teaching specific concepts in science.

This programme called Cognitive Acceleration in Science Education (CASE) was developed by Adey and Shayer in 1994 in U.K. The programme aims at bringing students upto the formal operational thinking stage by providing interventions in the 'Zone of Proximal Development'. The programme is subject-specific, containing specific concepts in each lesson. The project contains 52 lessons. The intervention programme has the following characteristic features.

(i) The teacher sets the problem in context using vocabulary familiar to the students and explaining the terms used in the problem.
(ii) In the next step the teacher introduces the situation of *cognitive conflict*. That is, the teacher provides such experiences to students which contradict their prior knowledge or understanding. Students feel that their existing knowledge is not sufficient to explain these experiences and they feel the need to construct new knowledge. This can lead to the students moving towards their zone of proximal development.
(iii) Students then move on to the *construction zone* activity. Here, students go beyond their current level of understanding and competencies. Teachers can help students to build up higher level reasoning patterns step by step.
(iv) Students need to reflect consciously on each step of their problem solving and recognise why they are doing this, what kind of results will be obtained using this method, what are the alternative ways of doing this, is this the most appropriate way of solving the problem and so on. This metacognitive activity becomes part of the cognitive thinking process.
(v) In the final step, students should be able to apply the new knowledge in different contexts. Students also need to bridge their new knowledge and previous knowledge.

The results of CASE experiment are reported to be highly positive. The lessons used in this experiment involved a lot of student-teacher and student-student interaction. With the

success of the CASE project, Cognitive Acceleration in Mathematics (CAME) project has also been developed in U.K. You may try these strategies with your students in your school context using your curriculum and, observe and monitor the progress of students on 'problem solving skills'.

5.4.2 Steps in Problem Solving

Problem solving method using cognitive and metacognitive skills has four main steps. All these steps require cognitive and meta-cognitive thinking skills.

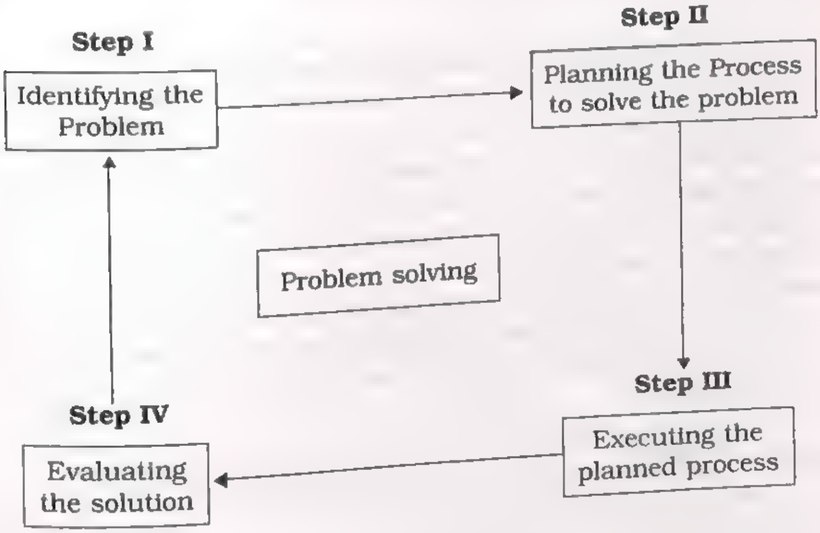


Figure 5.4

Step I: Identifying the problem

First step in problem solving is to find out what exactly is the problem. That is, the students must understand the problem and define it. To teach this step a problem situation is provided to the students and they are asked to disentangle relevant information from irrelevant information. Next, the students will represent the problem using the relevant information. A problem statement may also be given to the students asking them to explain these.

To understand a problem statement, students must understand the full meaning of all the sentences, that is, the meaning of all the words, logical structure of sentences and the

propositions used. Once the students understand all the sentences, words and propositions, they may be asked to redefine the whole problem. They may further be asked to categorise problems into different problem types.

To teach problem identification skills to students, problems that are new and meaningful to the students may be selected. The problems must be related to students' existing knowledge and must use familiar real life contexts. The selected problem must require students to transform methods of thinking and working and this must also help them to develop understanding of new concepts.

Step II : Planning and designing the method of problem solving

When the problem has been understood by the students, the next step is to plan and design the process of solving the problem. The process of problem solving can be based on heuristic or analogical approach. In *heuristic* approach the problem is broken down into a number of smaller steps and then the way to solve each of these steps is worked out. One may work backwards, that is, starting from the goal and moving back to the initial step or one can start working from the initial step and go on to the final step (goal).

Another approach used to solve problems is the *analogical* approach. In this approach one may search for solutions that one has earlier used to solve similar problems. Students may select one of these strategies to solve the problem and also describe the plan to solve the problem. Students may be asked to explain as to why they have selected this particular strategy and how each step will be solved.

Research shows that students who were asked to explain each step in their problem solving process were more successful than students who were not asked to do this (Gagne, 1965). After selecting the right strategy, students should be able to choose the right *algorithms* for each part of the problem.

An algorithm is the procedure, usually subject specific, to be followed step by step such as computations in mathematics. Heuristics explain the steps in problem solving and algorithms explain procedure in each step. If students start applying algorithms without properly defining and selecting the heuristics, they may not achieve the correct solution and even if they achieve

the results, they will not develop real understanding of the problem. The systematic planning and explaining of each step will help students in developing 'problem solving process skills'.

Steps III : Executing the plan

After planning various steps, the next step is to execute these steps. The executions of plan may require collecting data, organising data, analysing data, interpretation, drawing generalisation and conclusions etc. The process skills in execution of the plan may be classified broadly as follows:

Collection of data : The process of data collection may require observing, measuring, experimentation, getting responses on questionnaires, tests, interviewing etc.

Organisation of data : Once the data has been collected, it must be organised so that it becomes meaningful and communicative. The various processes in organisation of data are classifying, sequencing, ordering, comparing, assigning numbers, charting and graphing etc.

Analysis of data : The organised data is then analysed using appropriate statistical techniques so that predictions, generalisations and conclusions could be drawn.

Building solution ideas : The idea building process requires inferring, interpretation, decision-making, generalisation and explaining .

Step IV : Evaluating the solution

The fourth step in problem solving is the evaluation of the solution. In some cases, just checking the answer may give students some idea whether the solution is correct it not. For example, if the answer, when calculating speed of a bicycle, is 200 kms per hour, this indicates some mistake in the solution. Either the algorithms chosen are not correct or the heuristics are not correct. Estimation can sometimes help to check the correctness of the answer. Also, if there is any data in the question itself which could give some clue about the answer, they can check against it. Students need to check for all evidence and data that could contradict or confirm their answer.

Other method of evaluating the problem solution is to apply the solution to a new situation, that is, application of the answer may give some idea about the correctness and validity of the solution. Predicting, deriving operational definitions etc. may also help students in evaluating their answers or solutions.

5.5 Illustrations of Problem Solving

The examples given in this section illustrate the use of problem solving method in teaching different subjects across the curriculum.

5.5.1 Science and Technology

Problem solving method in science and technology can be used to develop the following problem solving skills/ behaviours among students.

- Curiosity and interest about environment/natural phenomenon.
- Observational skills
- Enquiry skills
- Identification of problems arising out of their environment
- Formulating hypothesis
- Testing hypothesis
- Conducting reliable experiments
- Revising ways to measure and gather data
- Draw conclusions and generalisation from data
- Reasoning ability
- Inducto-deductive thinking skills
- Evaluation and judgmental abilities
- Use of reliable sources of information

Example 1 The problem of 'how air gets heated' may be used to develop the concept of 'radiant energy' among students. The steps in problem solving could be as follows:

(i) *Stating the problem*- How does the air in the atmosphere get heated?

(ii) *Hypothesis* - Students may formulate the hypothesis that air gets heated by the sun's heat.

(iii) *Experiments to test the hypothesis* : Students must plan and design activities to test the hypothesis. Students may suggest and conduct activities of the kind given here.

Activity I : Hold your hand in the sunlight coming through a window pane. How warm does it feel? Next touch the glass of a window and feel how cold it is. From this activity students may conclude that sun heats their hands but does not heat the glass through which it passes.

Activity II : Take two similar pans. Place soil in one pan and water in another. Keep both these pans in the sunlight.

Place a thermometer in each pan and record the temperature of the soil and water every five minutes. Students will observe that soil gets heated faster. Next place both these pans in a cooler place where there is no sunlight. Read and record temperature every five minutes. Students will observe that soil also cools faster.

Activity III : At the beach, feel the warmth of the air over hot sand and its coolness over the cold water of the sea. Students may read and record the temperature by holding a thermometer in air above the hot sand and above the cooler water. Students can also make these observations near a river, pond, well etc. Students will observe that air over hot sand is much hotter compared to air above cooler water.

(iv) *Drawing generalisations* : From observations in activities 1,II and III students may draw the following generalisations.

- Sun warms objects such as hand, soil and water.
- Land heats and cools faster than water.
- Energy from the sun passes through atmosphere just as it passes through the glass window pane.
- Air is not heated by the sun or is only slightly heated, just like glass.

(v) *Drawing conclusion* : Energy coming from sun is in the form of heat and light energy. Radiant heat is like light in that it can travel through the near-empty space between the sun and the earth. The heat recorded by a thermometer is due to the motion of molecules and results only when radiant energy is absorbed by a substance like soil, sand, rock and water. In air, the molecules are fewer and farther apart and the motion they can build up by absorbing radiant energy is therefore less.

(vi) *Validity of the hypothesis* : The hypothesis that sun warms air is incorrect. Air gets heated due to its contact with earth objects such as sand, soil, rocks etc.

(vii) *Application of radiant energy:*

Activity IV: Blacken one half of a 3x5 inches card and leave it in sunlight. What do you observe and how would you explain the observed phenomenon? Students will notice that the blackened side which absorbs radiant energy is much warmer than the white side which reflects radiant energy. Try to find out which will be warmer during the day and at

night - land or water. During the day, land will be warmer than water and during night, water will be warmer than land. Wind blows towards land during day and towards water during night.

Example 2 : This example can be used to help students understand the principle of Archimedes and concept of 'force of buoyancy'.

Problem : Do all bodies in a given fluid experience same buoyant force?

Hypothesis : Students may hypothesis that all bodies in a given fluid experience the same buoyant force.

Experiments to test the hypothesis : Students may plan and design activities to test this hypothesis. Students may conduct activities of the following kind.

Activity V: Take a piece of stone and tie it to one end of a spring balance. Record the reading on the spring balance. Now dip this stone in a jar/ bucket containing water. Observe the reading on the spring balance as you slowly lower the stone in water. Students will observe that the weight of stone as indicated on the spring balance decreases as the stone is lowered in water but no further change is observed once the stone gets fully immersed in water. Next, take another piece of stone, smaller in size compared to the first one. Tie it to one end of a spring balance and record its weight as you lower it in water. Similarly take a third piece of stone, bigger than the first one and repeat the same experiment. Repeat this experiment with small slabs of glass, iron piece and wood block. Record your observations.

Object	Wt. in air	Weight when lowered in water			
		1	2	3	4
Stone 1					
Stone 2					
Stone 3					
Iron piece/nail					
Glass slab					
Wooden block					

Activity VI : Take two empty tin boxes (say A and B) and fill these up with pebbles. Make box A heavier than box B. Now tie box A to a spring balance and record its weight. Then dip this in a jar filled with water. Keep the jar in a big tray to collect the displaced water. Students may record the weight of the tin box as it is lowered in water. Students will observe that the weight of the tin box decreases as it is lowered in the water but does not decrease further when it is completely immersed in water. Note down the volume of water before and after the tin box is completely immersed in it. Weigh the water displaced by the tin box and collected in tray. Students will observe that the decrease in weight of tin box when immersed in water is equivalent to the weight of water displaced. Repeat this experiment with box B and compare the decrease in weight of box when immersed in water with the weight of displaced water.

Repeat Activity V taking alcohol/spirit/oil or any other liquid.

Drawing Generalisations : Students would draw the following generalisations.

a. The weight of an object (body) decreases as it is lowered in water but once it is completely immersed in water, the weight of the body does not decrease further.
b. The decrease in weight on dipping in water is different for bodies with different weight/mass.

Drawing inferences : Students may infer that when a body is immersed fully or partially in a fluid, its weight decreases. That means some force acts on the object (body) in the upward direction. This upward force exerted by the fluid (water in Activity V) is known as the Force of Buoyancy.

Drawing conclusions : Students may draw the conclusion that when a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it. This is known as Archimedes' Principle.

Validity of hypothesis : The hypothesis that all bodies in a given fluid experience same buoyant force is incorrect. Students may be asked to restate the Archimedes' Principle: "When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displace by it".

Applications of the Archimedes' Principle: Archimedes' Principle finds application in designing ships and submarines.

Lactometers, which are used to determine the purity of a sample of milk and hydrometers used for determining density of liquids are also based on this principle. Students may be asked to explain how these are based on Archimedes' Principle.

5.5.2 Mathematics

Problem solving in mathematics can be used to develop the following abilities.

- Inductive and deductive thinking
- Analytical thinking
- Critical thinking
- Creative thinking
- Drawing generalisations
- Values of truthfulness and honesty
- Interest in mathematics

Example 3 : This problem can be used to develop inductive-deductive thinking ability, to make generalisations and to introduce the concept of algebraic expressions and equations.

Problem : Select three/four three-digit whole numbers (both odd and even) between 100 and 999. Reverse the digit of each number and find the difference between the 'reversed' number and the original number. Can you draw the generalisations and an algebraic expression for the observed pattern?

Problem solution : The problem solving involves four main steps.

- Investigation of particular cases
- Finding a pattern
- Generalising
- Developing an algebraic expression.

(i) Investigation of particular cases.
Let the three digit number be 365 (odd number). Reversing digits gives number 563. The difference is (563-365) = 198 = 2 × 99 or 22 × 9
If the three digit number be 246 (even number), reverse number will be 642. The difference is (642-246) = 396 = 44 × 9 or 4 × 99

(ii) Finding patterns
Odd numbers
a) 365, (563-365) = 198 = 2 × 99
b) 135, (531-135) = 396 = 4 × 99

c) 357, (753-375) = 396 = 4x99
d) 159, (951-159) = 792 = 8x99

Even numbers

e) 246, (642-246) = 396 = 44 × 9
f) 468, (864-468) = 396 = 44 × 9
g) 268, (862-268) = 594 = 66 × 9

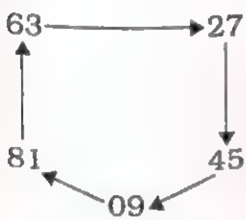
(iii) Generalising

- Difference formed from numbers and their reverse is divisible by 99 and 9.
- The difference is an even number in all cases.

(iv) Developing an algebraic expression

365 = (3 × 100) + (6 × 10) + 5.

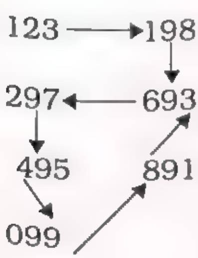
This can be represented as,
100A + 10B + C where ABC is the three digit whole number between 100 and 999.
So the difference between this number and the reversed number is,
100A+10B+C- (100 C+10B+A) = 99 (A-C)
Students may apply this to a two digit number and form the chain



63-36 = 27
72-27 = 45
54-45 = 09
90-09 = 81
81-18 = 63

All divisible by 9

Similarly draw chain for three digit numbers



321-123 = 198
891-198 = 693
693-396 = 297
792-297 = 495
594-495 = 099
990-099 = 891
891-198 = 693
693-396 = 297
792-297 = 495
594-495 = 099

All divisible by 99

The algebraic expression holds true for all three digit numbers. The algebraic expression for two digit number would be, 10A+B where AB is the two digit number.

Verifying the expression

$10A + B - (10B + C) = 9(A-B)$
$(10 \times 6 + 3) - (10 \times 3 + 6) = 9(6-3)$
$63-36 = 9(3) = 27$
$(10 \times 7 + 2)-(10 \times 2 + 7) = 9(7-2)$
$72-27 = 9 \times 5 = 45$
$(10 \times 5 + 4)-(10 \times 4 + 5) = 9(5-4)$
$54-45 = 9 \times 1 = 09$

This way students can understand the significance of algebraic expressions and learn how these are arrived at.

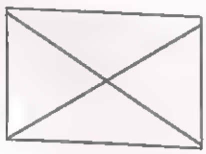
Example 4

Problem : How many diagonals does a quadrilateral have? A Pentagon ? A Hexagon ? A Polygon with n sides?.

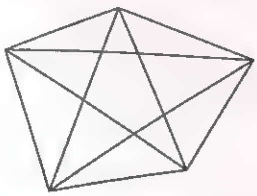
Problem solution again involves following steps.

(i) Investigating particular cases

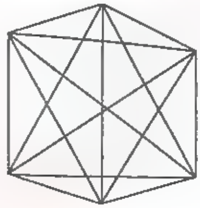
The number of diagonals in a quadrilateral will be 2.



The number of diagonals in a pentagon will be 5.



The number of diagonals in a hexagon will be 9.



(ii) Finding patterns

No of sides	diagonals
4	2= 4x½ (4-3)
5	5= 5x½ (5-3)
6	9= 6x½ (6-3)

(iii) Generalisation: A figure with n sides will have n x ½ (n-3) diagonals.

(iv) Verification of generalisation

n=9,	diagonals = 9 × ½ (9-3) =	9 × 3 = 27
n=3	diagonals = 3 × ½ (3-3) = 0	3 × 0 = 0

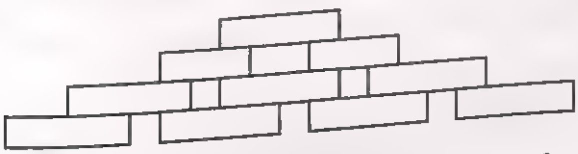
Example 5 : This example can be used to teach Arithmetic Progression (A.P.)

Problem: What is the sum of the first hundred natural numbers? By generalisation find out the sum of n natural numbers.

Problem solution : Some students may start adding 1 + 2 + 3 + — +100, others may work some pattern such as 1+100=101, 2+99=101, 3+98=101 and so on. There will be 50 pairs of 101 each giving required sum of 5050. To arrive at the generalised formula, students may do the following activities.

1. *Investigate particular cases:*

Activity VII : Complete the pyramid taking 4 note books as base. To complete the pyramid students would require 10 books. Sum of numbers 1,2,3,4 is 10.

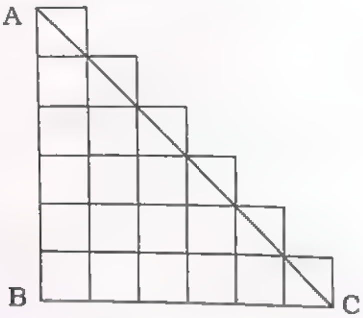


Similarly complete pyramid with three and five note books as base. Students would require 6 and 15 note books respectively to complete the pyramids.

Numbers	Sum
1,2,3	6
1,2,3,4	10
1,2,3,4,5	15

Ask students to work out the pattern.

Activity VIII : Arrange squares taking 6 boxes as base and one as top as show nbelow.



Sum of series 1+2+3+4+5+6 would be,

area of right triangle ABC+ 6/2

½ x 6x6 + 6/2= 18+3=21

Similarly, what would be the sum of 1,2,3,4———n numbers?

The sum of 1,2,3———n number would be,

S_n=(1/2) x nx n+(n/2) = (n/2) (n+1)

Recognising pattern :

$S_1 = 1$	$S_1 /1 = 1$
$S_2 = 1+2 = 3$	$S_2 /2 = 3/2$
$S_3 = 1+2+3 = 6$	$S_3 /3 = 6/3 = 2$
$S_4 = 1+2+3+4 = 10$	$S_4 /4 = 10/4 = 5/2$

If, we make the common denominator as 2, then pattern would be,

2/2,3/2,4/2,5/2,6/2,7/2————and so on.

Drawing generalisation : The generalisation on the basis of this pattern can be

$S_n /n = (n+1) /2$ or $S_n = n [(n+1)/2]$

Similarly work out generalisation for series 2,4,6————n and 1,3,5,7———— n.

Students will arrive at the general formula $S_n=n/2 [2a + (n-1) d]$,

where a is the first number and d is the difference between two consecutive numbers of a series.

Verification of formula : Students would verify the formula for different series and sequences such as,

For 2 + 4 + 6 + 8,
S_n= 4/2 [2 × 2 + (4–1)2]
= 2 [4 + 6] = 20
For 1 + 3 + 5 + 7,
S_n= 4/2 [2 × 1 + (4–1) 2]
= 4/2 [2 + 3 × 2]
= 4/2 [2 + 6] = 2 × 8 =16

Application : Encourage students to construct problems related to A.P such as :

(i) Find x such that 2,x and 14 are in A.P
(ii) Find y such at 3,y and 11 are in A.P
(iii) Find 3 such at 20,z, 40 are in A.P
(iv) Arrive at the general rule that arithmetic mean between two numbers a and b is (a+b)/2.

5.5.3 *Languages* : In language teaching, problem solving can be used to develop abilities such as:

- Analytical thinking
- Critical thinking
- Hypothetical-deductive thinking
- Creative thinking
- Cooperative attitude
- Social competence
- Emotional competence
- Creative writing
- Decision making
- Reflective thinking

Problem solving also develops skills of reading, comprehension, speaking and writing.

Example 6 :

Problem: A detective story without ending is given. Students are required to solve the mystery given in the story and to suggest the ending.

Method: Divide the class into 4 or 5 groups and ask each group to solve the mystery and come up with their own solutions. They must write down the solution, giving reasons. Different groups can then discuss their solutions in the whole class.

Example 7

Problem : A study is given where a criminal trial is discussed. Students are required to give re-verdict of the jury.

Method : The class is divided into four or five groups. Each member of the group reads the story and then the group writes the re-verdict of the jury. Next, different groups present their re-verdict of jury before the whole class.

Example 8

Problem : Take a passage from the text book or supplementary reading book. In the passage delete 6^{th} or 7^{th} word from the text. Ask the students to fill up the appropriate words so that the passage becomes meaningful.

Method : This problem is to be solved by each individual. The students would then present in the class their completed passages. In evaluating the corrected passages, acceptable word method may be used instead of exact word method.

Example 9

Problem : Reports from four newspapers on a controversial issue such as 'Freedom of Press' or 'Role of Private Sector in Education' are provided to the students. Ask the students to read the reports and give their judgment as to:

(i) Which newspaper has the most objective reporting and is least biased ? Give instances.
(ii) Which newspaper has the most facts? Enumerate the facts in each paper.

5.5.4 *Social Sciences* : In social sciences, problem solving method can be used to develop abilities such as:

- Analytical thinking
- Critical thinking
- Relating cause and effect
- Rationalising and reasoning ability
- Social values
- Judgmental ability

Example 10

Problem : Why did the revolt of 1857 fail?

Problem solution requires analysing various events of the 1857 revolt. The class may be divided into 4 or 5 groups. Each group will analyse the total situation and relate cause and effect. The

students may work on aspects such as:

- What was the role of the common man in that revolt? Was public participation effective or not?.
- How was the revolt carried out? What kind of weapons were used? Were the rebels united?
- How did the Britishers tackle the whole situation? What was their strategy?

When each group has worked on different dimensions, analysed the total situation and prepared their solution, they may present their solutions before the whole class.

Example 11 :

Problem : How did Mahatma Gandhi influence and force the Britishers to leave India without violence?

Problem solution : Again the teacher may divide the class into 4 or 5 groups. Each group would read about the freedom struggle and Mahatma Gandhiji's role in it. The students may focus on points such as :

- Civil disobedience movement, 1920
- Quit India movement, 1942
- Non-cooperation movement, 1920

Students would analyse how these movements were initiated, how public participation was sought, the important events of these movements etc. Each group would then present their solution before the whole class. Discussion would help students to reflect upon their own solutions.

5.6 Summary

Problem solving method has a long history and its philosophy is rooted in John Dewey's philosophy of Pragmatism. The recent constructivist philosophy proposed by Piaget and Vygotsky also supports problem solving method. The psychological view of problem solving is different in behaviorist and constructivist theories. In behaviorist theory, learner is a passive, extrinsically motivated individual whereas in constructivism, learner is an active, intrinsically and socially motivated person with support by adult or a more knowledgeable person.

Different psychological theories such as information processing theory, Gagne's conditions of learning, Piaget's cognitive model and Vygotsky's social constructivism propose different processes of problem solving by humans. Recent

cognitive theories state that problem solving involves meta-cognitive and cognitive abilities. Thinking abilities are central to the process of problem solving.

Problem solving involves four main steps:

(i) Identifying the problem
(ii) Planning the process to solve the problem
(iii) Executing the planned process
(iv) Evaluating the solution

Higher levels of learning can be achieved through problem solving. These include reasoning ability, hypothetical, deductive and inductive thinking, judgmental ability, enquiry, observational skills, values of honesty and cooperation. Problem solving method can be used across the curriculum in all the subjects such as science and technology, mathematics, social sciences, language, arts, etc.

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6

Investigatory Approach

6.1 Rationale

Enquiry into the phenomenon to understand the processes is one of the natural ways by which students construct new knowledge. The enquiring process in science begins with casual observations and is carried through inductive or deductive reasoning, hypothesising, hypotheses testing to end in generation of knowledge and so on. The processes in this endeavor such as observing, inferring, measuring, predicting and experimenting constitute the process of investigatory method. Teaching at secondary school level is aimed at developing investigating minds through the processes of science. Investigatory method is particularly useful in teaching science and social sciences.

To teach science or social science, the teacher not only must know the subject matter, but must also know the nature and methods through which these can be effectively learnt. To read about science is one thing, but it is something else to learn about science in the laboratory - making measurements, moving balance weights and devising experiments. One must get involved in the act of doing. By experimenting or investigating in the laboratory or in other field conditions, one not only gets a real knowledge of science and laboratory techniques, but also begins to gain an understanding of the nature of the subject matter. The spirit and process of inquiry in science cannot be taught through talking and cannot be learnt only by listening. Science involves activity.

6.1.1 Objectives

After reading this chapter, you will be able to:

- develop an understanding about the psychological and philosophical bases of investigatory method;

- develop an ability to analyse a science lesson in terms of scientific skills, processes, experiments and /or ideas;
- plan science instruction for a given topic/activity at the secondary level;
- develop teachers' understanding of the relationships that exist between processes of science and of how children process science; and
- develop skills involved in an investigatory method and help plan investigatory projects with the help of processes of science in the area of secondary science curriculum.

6.2 The Philosophical and Psychological Bases

Many innovative practices, including investigatory approach were developed early in the twentieth century through questioning of the individual, personal and social purposes of education and formalism of the traditional classroom where the cultivation of knowledge and character took place by recitation and rote learning within a narrowly constrained curriculum. The intellectual origins of the investigatory method were associated with child study and scientific movement and the educational progressivists' stress on the experience of the learner in the environment, development of the whole person, relevance of the curriculum to sharpen skills and the need for flexibility in schools. It emerged as part of the challenge to formalism in the classroom and reflected the increasing freedom of intellectual and physical movement offered to students in practical activities

In order to understand the investigatory approach, one needs to know about the nature of learning and its dimensions. The following list of continuums about learning in science provided by Nott and Wellington(1993) suggest some interesting dimensions to learning of science which helps in extending one's understanding of investigatory approach in science.

- Relativism vs positivism - generating from observations to general laws versus forming hypotheses and testing observable consequences.
- Contextualism vs decontextualism - science interdependent with or independent of cultural context.
- Process vs content - science characterised mainly by process or by facts and ideas.
- Instrumentalism vs realism – science as providing ideas which work versus a world independent of science perceptions.

Each of the above continuums highlights key tenets of science. It is important that one understands about these ideas and their influence in investigatory approach of teaching science.

Investigatory approach not only involves understanding about the phenomena around us, but also reaching possible conclusions, exploring relationships and explanations between ideas and events. It includes the testing of ideas and the proposal of new theories and questions which are subject to change all the time since our ideas, skills and knowledge are developed through new research and evidence. It involves collaboration and cooperation between individuals and groups which should be a part of investigatory approach when applied to science instruction in schools.

Learning starts with pupils interacting with their environment. In learning, the process is probably more important than the product. Piaget, a Swiss psychologist said that good teaching involves presenting pupils with situations in which they put their questions to nature, trying things out to see what happens, manipulating things and symbols, posing questions and seeking their own answers, comparing what they find one time with what they find at another time and comparing their findings with findings of other children. Piaget's psychology has provided a classification of mental processes in a hierarchy helping one become aware of children's mental development and thought patterns.

An accumulated body of knowledge from the field of child psychology has revealed that children's intellectual development evolves through stages as they progress from early childhood to adolescence. An awareness of these stages and the characteristics of children at each stage can do much to provide guidelines in devising learning experiences commensurate with the child's intellectual skills.

The four stages of cognitive development described by Piaget are as follows :

Sensory-motor stage (0 – 2 years)

- This stage involves the child from birth upto 2 years of age.
- At this stage, the child's cognitive ability is very poor.
- The child is very much dependent on his parents.
- The linguistic ability of the child is not developed.
- The child is not conscious of his own self.

- The child at this stage is only capable of seeing or perceiving things.
- Based on the linguistic ability of the child, this stage is also called pre-verbal stage.
- When the child reaches the age of 1-2 years, the ability of identifying the objects around begins to bloom.

The child believes that the entire world is only the world present around him.

Pre-operational Stage (2 – 7 years)

- This stage involves the child from 2 years to 7 years of age.
- The cognitive structure of the child is better developed than in the previous stage i.e. the sensory motor stage.
- As a result, linguistic ability develops which was very poor initially. The child begins with simple words and gradually can speak small sentences.
- The child perceives, identifies and also symbolises them with a certain name.
- Gradually he is able to use an organised language.
- Initially he believes only in what he sees and slowly tries to comprehend things better.
- He only accepts what he sees.
- He lacks the ability to coordinate different variables. The effect of changing the variables also cannot be understood.

Example: Two balls made out of equal quantity of clay are taken. One of these balls is prolonged and made into a snake. Now, if you ask the pre-operational child, whether snake contains more clay or the ball, she may say that snake contains more clay because pre-operational child perceives that snake is bigger.

Example: Take equal quantity of water, say 500 ml in two vessels of different diameters. Label these as A (narrow) and B (Wide). The level of water in vessel A will be higher compared to B. Pre-operational child perceives that quantity of water in vessel A is more than vessel B. Now empty vessel B and pour water from vessel A to B. The child still perceives that water in vessel B is less compared to water earlier contained in vessel A.

The idea of conservation and reversibility is not understood by her.

Concrete Operational Stage (7 - 11 years)

- This stage involves children from 7 years to 11 years of age.

- As the name suggests, the cognitive structure becomes a little more concrete. As a result, the child is able to perform numerical operations like addition, subtraction etc. but with an elder's assistance.
- The concepts of reversibility and conservation can be understood and also applied in various situations.
- The concrete operational child bears the capacity of reasoning out on objects which are concrete.
- Here the child learns new concepts like seriation. Example: placing various objects in a serial order based on single criteria or multiple criteria (multiple seriation).

The ability to identify also helps him to classify the given set of objects. Example: Apart from placing in an order, grouping of these objects is also possible (classification).

Formal Operational Stage (12 – 15 years)

- This stage includes children from 12 years and above.
- The cognitive structure is very well developed and is also matured.
- Reasoning out capacity leads to the capacity of arguing, debating and also questioning.
- We cannot satisfy them just by telling. They believe only when they see with their eyes.
- Gradually the thinking ability, from being concrete, extends upto abstract thinking. Example: Based on the present situation, they can guess the future.
- The most prominent change at this stage is the emergence of logical abilities like:

  A. Deductive Thinking
  B. Inductive Thinking
  C. Reflective Thinking
  D. Inter-prepositional Thinking

The above summary of the cognitive development of children is admittedly, very brief, providing a basis for the investigatory approach of teaching. Teachers must provide to the learners such learning situations according to their level of development that require them to conduct experiments, think reflectively and draw generalisations. The paramount concern of teachers, therefore, should be the designing of experiences for learners to ensure that they have opportunities to perform and practise activities appropriate to their level of cognitive development.

It is seen that most of the laboratory work deals with the particulars, and many of the investigations are structured. If knowledge resulting from a laboratory experience is to have validity, some structure which includes organised procedure must be provided. The skills and the steps involved in the investigatory method are given in the following sections.

6.3 Skills Involved in the Investigatory Method

What is involved in a scientific investigation? What is the difference between investigations and experimenting? Why is it so important to work in a systematic way?

An *experiment* is an activity to confirm or disprove a hypothesis. An investigation is an activity to verify what is known or to gain new skills. What is involved in carrying out an investigation is discussed in this section. This will provide the context for analysing the scientific process and the skills, knowledge and attitudes needed. The investigation is divided into sections to enable one to explore the process as one progresses through the task.

Table 6.1 adopted from *Progression in Primary Science* (Hollins and Whitby et al. 1990) is a list of the key process skills alongside a more detailed breakdown of what each might involve. Carrying out investigations is a very important way of developing skills and understanding the scientific process. It is only by doing activities that we understand the finer detail and the need to constantly evaluate our ways of working. It also provides a very real context to develop our thinking and relate our previous knowledge to new experiences.

Table 6.1

Observing	Looking closely at similarities and differences Comparing and contrasting Regularities and irregularities What do you notice about....type of questions Describing patterns Ordering and sequencing events
Raising questions	Raising questions whilst working Restructuring questions into useful ones for investigation Defining testable questions

Measuring	Selecting appropriate measuring techniques Recognising when to use estimating Using measuring devices with accuracy Recognising arbitrary nature of units Recognising need to repeat and check measurements Recognising variability and reliability of measurement
Hypothesising	Attempting to explain observations in terms of concepts or principles Recognising the fact that there are several possibilities to explain phenomena Applying knowledge already acquired Using the explanation to make predictions of something that can be observed or tested
Planning	Defining the problem Identifying which variables are to be controlled Identifying the independent and dependent variable Considering how observations made will be used to solve problems Selecting appropriate equipment, materials Giving careful consideration to order of working Considering methods of recording findings
Interpreting	Eliciting what can be deduced from the observations and measurements taken Recognising sets and subsets Making use of keys or taxonomies Appreciating the tentative nature of conclusions Making generalisations Making and justifying inferences Making predictions based on patterns
Communicating	Following verbal instructions Describing activity orally Using diagrams/drawings and writings to tell about findings Following written and diagrammatic instructions Using tables and graphs, models etc. to represent information

	Selecting appropriate ways of presenting information Responding to a range of audiences, selecting appropriate methods of communication Listening to reports/ideas of others and responding to them Contributing to group discussion Using secondary sources to acquire information Using information technology as appropriate

6.4 Steps Involved in the Investigatory Method

The steps involved in the investigatory method are as given below:

(i) Posing useful questions

The teacher can provide his own topic for investigation or provide a suitable context for raising questions and investigating some of them.

Harlen (2000) categorises questions into four types and this provides a useful way to classify questions into investigations or those that just need an answer or further observation or discussion. Investigations cover a wide range of activities and need not include experimenting alone. They could include all or some of the following :

- research into current ideas using secondary sources
- modelling ideas
- observing
- hypothesizing and experimenting to test ideas

The kind of questions posed will define the breadth of the investigation but not all questions lead to an investigation. Defining what is meant by best is an obvious starting point and may give rise to a range of activities before any decisions are made about testing. The discussions and the decisions should determine how one plans, carries out and evaluates the experiment. When the findings are reported, it is necessary to include these decisions and ideas in the report as it will determine how the reader views the findings and interprets the results.

(ii) Planning an investigation

Having raised a suitable question to investigate, it is important to find a way to do this to answer the question posed. This is not

always easy. Many scientific investigations have been criticised because the methodology chosen did not allow the question posed to be answered. The steps required to answer the question posed are hypothesising, predicting and planning.

a) Hypothesising and predicting : Predicting and hypothesising are often linked together but they do have distinctive features. Predicting is saying what you think will happen as in, which will be the best fabric for keeping our hands warm. In predicting this, we may also include a hypothesis, i.e. a reason why we think so, based on previous knowledge, research and experience. Often people have ideas about why they have predicted what they have, eventhough they do not articulate these. Hypothesising is very much about using previous knowledge, evidence and observations to formulate tentative theories about why things happen in the way they do. It is an important skill to develop and helps us to make sense of our understanding of the world as we transfer this knowledge from one situation to another.

b) Planning : The next step is to plan and order our work so that we gather the information we need to answer the question posed. What kind of evidence do we need to be able to do this? First we may need to consult resources such as books and collect together appropriate apparatus to help us decide what to do and in what order. The AKSIS Project (Association for Science Education and King's College Investigations in Schools [Goldsworthy, 1998]) lists six types of investigations with sample questions from the project to exemplify the kind of investigations and type of question to be answered.

- *Fair testing :* These investigations are concerned with exploring relations between variables or factors. For example:
  - What affects the rate at which sugar dissolves?
  - What makes a difference to the time it takes for a paper spinner to fall?
  - Which is the strongest bag ?
- *Classifying and identifying :* Classifying is a process of arranging a large range of objects or events into manageable sets. Identifying is a process of recognising objects and events as members of particular sets, possibly new and unique sets, and allocating names to them. For example :
  - What is this chemical ?
  - How can we group the invertebrates?

- *Pattern seeking* : These investigations involve observing and recording natural phenomena or carrying out surveys and then seeking patterns in the findings. For example:
  - Do dandelions in the shade have longer leaves than those in the light?
    Where do we find most snails?
  - Do people with longer legs jump higher?
- *Exploring* : Pupils either make careful observations of objects or events, or make a series of observations of a natural phenomenon occurring over time. For example,
  How does frog-spawn develop over time?
  What happens when different liquids are added together ?
- *Investigating models* : These are investigations that explore models. For example:
  - How does cooling take place through insulating materials ?
  - Does the mass of a substance increase, or decrease, during combustion?
- *Making things or developing systems* : These investigations are usually technological in nature, but have a high scientific content. For example:
  - Can you find a way to design a pressure pad switch for a burglar alarm?
  - How can you make a weighing machine out of elastic bands?

You can see from the list that there are a variety of ideas for practical activity in science. The emphasis in our investigation of making sure it is a fair test will place it within the fair testing category with strong links to investigating models. It is important now to ask some key questions in order to make our test fair so that we are comparing like with like and not changing more than one variable at a time. The list of questions one needs to ask at this stage includes some or all of the following :

- What do we need to measure?
- What shall we use to measure?
- What do we need to change?
- What do we need to keep unchanged?
- How will we measure the changes as They occur?
- How often will we measure?
- How will we record this data?

- Shall we use a table or chart to record?
- If so what will it look like?

It is important in an investigation to remember that it will involve you in changing something to test the effect and measuring the change. List all the possible things that you could change in your investigation. The factors that one could change are called *independent variables* and the variables on which you are testing the effect of changes that you have made are called *dependent variables*. For example, testing the effect of different fertilisers in different amount of doses is an independent variable, and the effect of administration of fertilisers in different amounts on growth of plants is a dependant variable. The variables like temperature, water and humidity that are kept constant are known as *control variables*.

(iii) Designing and conducting the experiment

This involves making use of the questions that were raised in order to work out the order sequentially which says how to go about and what changes to be brought about, how to measure the changes and so on. At each stage, one should list the skills, knowledge and understanding that one had used to carry out the investigation. Thurber and Collette in their book *Teaching Science in today's Secondary Schools* discuss about open-ended experiments. They indicate that these experiments are different from routine lab exercises. Their characteristic features are

- An experiment is done to answer a question.
- The outcome is supposed to reveal Nature and hence the experimenter does not know the outcome of the experiment before performing it. There is every possibility that the outcome is erroneous if the experiment is not performed judiciously and with open mind.
- The design of the set up and the procedure of the conduct of the experiment are solely determined by the performer. For that he has to understand the problem thoroughly and also be aware of the reasons for conducting it.
- The experimenter makes his own observations and draws his own conclusions after attacking/questioning every view point, and
- Conclusions are drawn by the experimenter on the basis of data collected by him. Thus he has to sequence the data, interpret it and draw conclusions as per his ability. These

should naturally lead to other problems, other experiments and formulating new hypotheses. If new ideas/investigations come up through the open ended experiments, the budding scientist is thrilled and encouraged to solve more problems. Thus, the laboratory work can be so organised that the students take active part with utmost capability i.e., this can be made student centered and student activated.

The beauty of open-ended experiments is that there is no bar on time, place, space or the branch of science concerned. Thus, it is a project which involves investigation, discovery and finding out something which was not known to the student before.

- *Conducting the experiment:*

While conducting the experiment, the investigator must know what he/she is trying to find out and to answer what questions, other important things that an investigator must know are:

(a) What is the hypothesis?
(b) What are the articles/equipment 'extensive list and necessary diagrams' needed?
(c) What is the theory behind the experiment?
(d) How will the experiment be performed? An experiment to be performed has to progress systematically with objectives in view. Hence different parameters related to it should be analysed first. The choice of the method is then decided depending upon the variable quantities involved. The method suggested must conform to:
  - financial strength, and space-wise capacity and availability of resource personnel in the Institute,
  - ability of the performing age group, and
  - controls/restraints necessary to adhere to.

Thus the method should be lucid and should yield reasonable results with the use of average care.

- *After conducting the experiment :*

(a) How was the data collected? It should properly indicate the extent to which the uncertainty in the measurement lies. It should always be remembered that it is better to err on the side of making things too large instead of making them too small (e.g. measure the magnified image rather than diminished image of the object when it is inaccessible). It is also advisable to tabulate the data properly.

(b) How was the data interpreted? It is desirable to include graphical relation between two variables if there exists a mathematical relationship. Interpretation should be done in the light of known principles and experimental findings.

(c) What are the conclusions?

(d) What are the sources of error? How were the errors of the experiment minimised?

(e) What are the scopes for further investigation?

(f) Is there any educational/practical/industrial utility of the investigation?

- *Review*

  (a) What reference materials were used:
  - at the formulating stage?
  - at the hypothesis stage?
  - at the experimental stage?
  - at the interpretation stage?
  - at the application stage?

  (b) Has the summary been prepared for its quick review?

  (c) Have the results been disseminated for criticism/ discussion?

  (d) Has proper acknowledgement been made?

- *How to conclude*

When an experiment has been successfully performed the investigator should be allowed to interact with other persons of other groups, may be along with an expert. After discussion, salient features of the discussion should be noted and pondered over. Finally, suggestions for further investigation/modification should be made to benefit others. If the experiment is meant for wide utility, a feedback from the users should also be sought. To understand natural sciences or social sciences, one must understand the process (means of investigation) as well as products (knowledge that results from investigation).

Few investigations that can be tried

- Investigation into water intake with food we eat.
- Investigation into disappearing molecules.
- Investigation into a plant under water.
- Investigation into substances in soil.
- Investigation into growth of a plant.
- Investigation into growth of microbes on a piece of bread.
- Investigation into the hatching of an egg.

- Investigation into what happens when a plant grows.
- Investigation into rate of respiration.
- Investigation into nature of light.
- Investigation into cohesive and adhesive forces.
- Investigation into force of surface tension.

(iv) How to record, analyse and interpret findings

We could use several ways of collecting and recording data including a chart, a prepared table or a computer spread sheet. Depending upon the kind of investigation, the ways of recording the data have to be planned. For example, to investigate upon the importance of leaves to the growth of a plant, the students may be asked to design an experiment that include the plants with leaves and without leaves. The data may be recorded in the following manner.

Plant	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
Without leaves							
With leaves							

The data recorded must yield to patterns or provide scope to see links between the factors that one is testing. The data can also be recorded and presented in the form of a graph which provides a comparison of the factors under testing. This should be followed by interpreting the results. For example, which fertilisr helped in the plant's growth, which plant did not grow, which plant took long time to grow and so on.

(v) Evaluation

The investigation may be repeated several times to see if the pattern repeats itself. The more evidence one gathers to support the outcome, the more sure one can be of any conclusion that can be drawn. At this point, one should look back at the predictions and hypotheses that were made. Were the results as expected? Can the reasons be supported for the choice one made ? Is there any need to explore more avenues to be able to speak with more authority about which fertiliser was fit for plants' growth? It is necessary to raise questions about the modifications

or adjustment of procedures and equipment as one went about experimenting. Having gained some results and drawn some conclusions it is important to evaluate the work, to decide upon how rigorous one's working and the findings were. This will help one to decide whether one should repeat the experiment or redesign the investigation before starting again.

6.5 Illustrations

Some of the illustrations given below show that investigatory approach can be used to teach all the subjects across curriculum.

6.5.1 Science

The examples discussed in this section illustrate that investigatory projects can be conducted in the laboratory. The experiments can also be open ended, different from the routine lab exercises.

Example 1

Investigation into the soil

Soil covers most of the land surface of the earth. It is made up of mostly three ingredients - sand, clay and humus. The composition of soil determines its texture and fertility. It facilitates shelter and vegetation. During a year cycle, it undergoes change in chemical composition and physical behaviour.

The factors that affect soil properties are: location – geographical; environment – hill, river, sea, forest or habitat; strata – upper surface or inside surface; colour – chemical composition; grain size – vicinity of mines; extent of exposure – sun, rains, wind; presence of humidity; organic and bio material etc.

An investigator observes a sample of the soil and decides for a parameter which he can control to see changes he can effect on a dependable property. In doing so, he should convince himself that he would try to maintain all the other factors constant at some level of accuracy. A student of natural science would be interested in every scientific aspect whence he can integrate every investigation into a single theory.

To study hardness/compactness of the soil

Material neededd – a tennis ball, a meter scale and a survey vehicle. *Procedure* - Undertake a field visit to a place where only

hardness of soil varies (independent variable). Release the tennis ball from a height of one meter on a flat soil surface. Count the number of bounces it survives. Tabulate the observation.

Sl. No.	*Type of soil*	*Number of Bounces*
1.	Agriculture field	-
2.	Pathway	-
3.	Near river	-
4.	Near mine	-
5.	Hill top	-
6.	Household floor	-
7.	Forest	-

Questions

How do you claim reproducibility of the result ? The result is different during different seasons. Why ? Why do you stick to 1 m height ? What do you expect with balls released from other heights ? Which among the above are experimental groups ? Which is the control group ? What do you expect with balls of other sizes and materials ? Why should the surface be flat and leveled ?

Investigatory question :

What does the property-the bounce-indicate? Should you restrict to only above seven samples ?

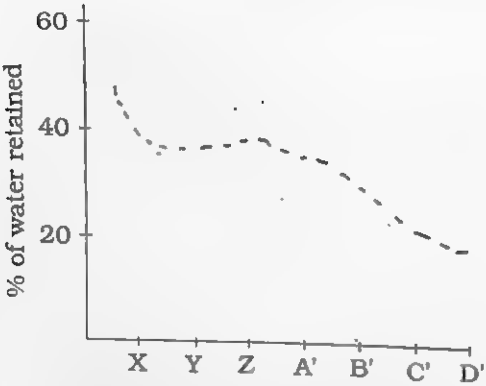
Water retaining capacity

Material – funnels with filter, 7 soil samples, 100 g each from above places, 1000 ml water, collecting and measuring jars, stop clock.

Procedure : Pour 100 ml water on each sample and allow it to stand for 5 minutes. Transfer these mixtures to different sets of funnels fitted with a filter. Collect the filtered water in a set of measuring cylinders. Compare their volumes. (Fig. 6.1)

Questions

Which sample retains water least? Which sample retains water most? Which sample becomes bright in colour? Which sample becomes dull on wetting? Why should you use same quantity of water? What will happen if water from different sources is used?



* name of the sample
(Terminal set)

* Arranged in the order of
decrease in water retaining capacity

Fig. 6.2

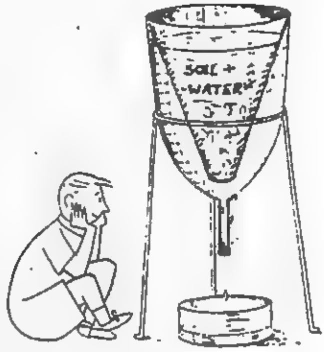


Fig. 6.1

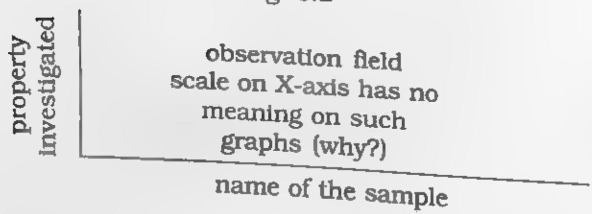


Fig. 6.3

Investigatory question

Note filtered water from each sample every 5 minutes. Draw curves between percentage of water retained and name of the sample for different time intervals on the same graph as shown above for terminal set. (Fig. 6.2) Do you observe any consistency? Reason out. Find answer to question raised in Fig. 6.3.

Percentage of sand in soil

Material – Bucket full of water, 7 soil samples.

Procedure : Take 100 g of sample at a time. Wash it in a fine mesh. Sieve several times and dry it under the flame. Find the ratio of left over sample to original quantity of the sample.

Questions

Which sample is most sandy and which sample is least sandy ? Does sand play a role in making of a particular location?

Integration of experiences from the three investigations:

Tabulate the properties sought in the three investigations together as under (enrichment of science involves integration of every experience from a variety of investigations):

Sl. No.	*Type of Soil*	*Number of bounces*	*Water retained in percent*	*Sand present in percent*
1.	Agriculture field			
2.	Pathway			
3.	Near river			
4.	Hill top			
5.	Near mine			
6.	Household floor			
7.	Forest			

What are the results of your investigations as supported by the table ? Write factful sentences like :

Soil near river is *sandy.*

Soil near mines is *hard.*

Water holding capacity is due to adhesion of water to soil.

pH of the sample is due to chemical substances present in the soil.

Try to collect vegetation/plants from the places (around) which was field of your study and answer – on which type of soil do the most different types of plant grow? What plant was common at all places? Name the typical plants representing particular soil.

Further investigations can be:

To study pH of different soils.

To study colour of different soils.

To study density of different soils.

To study smell from different soils.

To study micro organisms in the soils.

To study effect of heating on the soil.

To study chemical composition of the soil.

To study soil under a microscope.

To survey usage of the soil in terms of industry and as human resource.

Example 2

Investigation into reflection from a glass plate

When light falls on the *smooth* plane surface of a glass slab, a fraction of it is reflected back and a fraction is transmitted. If the glass slab is thick, a part of it may be absorbed also. If we take 'I' to be the intensity of the incident light then (mathematically) from the conservation of energy,

$$I = rI + tI + aI$$
$$\text{or} \quad r + t + a = 1$$

where 'r' is the reflectance, 't' is the transmittance and 'a' is the absorbance of the glass slab used. If we create a situation where 'r' approaches 1, we can say that reflection is dominant. The surface responsible for this phenomenon is called reflecting (or white) surface or mirror. If 't' is made to approach 1, the slab is transparent. Thin films nicely show such a behaviour. If however, 'a' tends to 1, the surface is absorptive or black. In real life situation, all the three processes occur simultaneously. Their proportion depends on the situation created.

For reflection, the essential criterion is the smoothness of the surface. Further, the laws of reflection (viz. angle of reflection and angle of incidence are same in magnitude; the incident ray, reflected ray and the normal to the surface through meeting point of these rays all lie in a plane) hold good. If incident rays emanate from an object, the reflected rays give sensation of the object kept behind the surface. This is called the image.

With this background it is natural to assume that the thin smooth plane glass slab will not reflect light (or it cannot be employed to form an image of the object).

Let us design the experiment to test the validity of this assumption. However, before choosing the set up, let us remember that we should examine all the parameters involved (or identify those which might play a role) and then choose one as independent variable that affects the result. We will also identify another as dependent variable (keeping all other parameters constant). Let us list our probable parameters.

1. Intensity and colour of light – a) emitted by the object, b) on the side of the object, c) on the opposite side of the glass plate.
2. Orientation of the glass plate with respect to object.
3. Medium and background on either side of glass plate.
4. Colour and brightness sensitivity of the observer.

Since we are concerned with reflection, let us keep variants 2, 3 and 4 identical for the whole set of experimentation. Let us keep colour of light used as well as the brightness of the object same. Now we are left only with intensity of light on either side of the glass plate as variant.To create such a situation, we place a thin glass slab measuring 15 cm×15 cm supported in a vertical plane on a table. Place a doll in front of it. Arrange two identical bulbs on either side of the glass plate whose intensity can be varied. Cover the arrangement with a box and make a slit from where image of the doll after reflection can be viewed as shown in Figure 6.2.

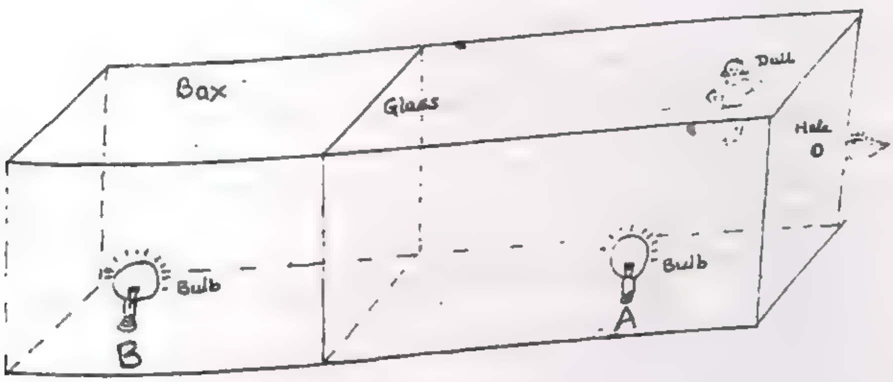


Figure 6.2

Procedure

Set I

Look through the slit when both bulbs are off. Record your comments. Light bulb A by passing a current and again record your observations. Repeat this procedure every time after increasing current through the bulb. Now answer the following questions :

- What role does light from bulb A play?
- What happens to the image when intensity of light is increased?
- Is the location of bulb A significant in any way? If so, how ?
- What do you expect to happen if only doll is lighted? Try to confirm your answer by placing the bulb in the place of the doll ?

- Should you darken the covering box from inside ?

Set II

Keep the bulb A off and record your observations for successively increasing the intensity of light from bulb B. What is the difference in the two situations ? Draw as many conclusions as possible from the two sets of observations.

Set III

Keep bulb B lighted at some intensity and increase intensity of A after each observation successively. In what respect is Set III useful? Comment whether Set III substantiates your earlier conclusions.

Rate according to importance the following statements on the basis of your observations.

- The brightness of the object is the dominant factor for reflection to occur.
- Intensity of light in the object side of the glass plate plays an important role.
- Intensity of light on the other side should be negligible in comparison to intensity of light on the object side of the glass plate.
- Reflectivity depends on relative intensity of the light on either side of the glass plate.

Now should you draw final conclusion or undertake further experiment? Justify your answer.

Further investigations can be:

Take a fixed intensity of light but change colour combination on either side of the glass plate. What is the strange result you come across? Explain it on the basis of known facts (viz. an object reflects its own colour and absorbs all other colours. An object is difficult to locate if the colour of the light incident on it is the same as its own colour).

Further investigations can be:

Look critically into following situations you come across in daily life and try to explain.

- Sitting at night in a lighted room having glass windows, you are blind for outside world but an outside viewer can see your activity.

- The bus driver puts off light in the bus while driving in the night.
- Light from a vehicle coming towards you during night travel perturbs you most.
- People prefer to paste a thin coloured transparent sheet to the glass of their cars.
- You can view the reflection of objects in still deep waters.
- Reflection is best observed with thin oil films on the surface of water.
- A little water on tar road serves as a good reflector.
- In hot sun, mirage phenomenon takes place.
- To avoid reflection, grounded glass is used.
- To avoid or facilitate reflection only one surface of glass is modified/treated with adhesives.

6.5 English

Example 3

A reading passage on Ramanujan which describes his earlier life.

Method: Divide the class into 3-4 groups and ask each group to find out a specific aspect of his life, for example,

- One group could find out about his early adulthood.
- Another group could find out about his days at Cambridge, especially his relationship with Hardy.
- Still another group could find out about his sickness leading to death.

Abilities to be developed

1. Critical thinking
2. Decision making
3. Values

Language ability : Reading and writing skills

Example 4

Idioms relating to parts of the body. For example:

- He's got a finger in every pie
- Get it off my chest
- Had to pay through the nose
- Got to hand it to her.

Method

- Ask the children to collect 20 idioms relating to body parts.
- Look up the dictionary and find out the meaning of the idioms.
- Then write a story using these idioms.

This project could be an individual effort or a collaborative effort.

Abilities to be developed: Creative thinking
Language skill: Writing

Example 5

Reading passage : Kathmandu by Vikram Seth from Steps to English (Class IX, NCERT, 2002).
Method : An excellent passage for English across the curriculum. Get the children to find out about certain features of Kathmandu.

- Geographical situation
- Description
- Population
- History
- Tourist interest
- Politics in Nepal

Abilities to be developed: Analytical thinking
Language skill : Reading and Writing.

6.6 Summary

The investigatory approach was developed in early twentieth century through questioning of personal and social queries in the traditional classrooms where learning took place through recitation and rote methods within narrowly constrained curriculum. The psychological developments in the area of child development and the educational progressivists' stress on the experiences of learner in the learning process gave a new dimension to this method.

Investigatory approach was viewed as a scientific method of finding answers to the questions. The method gained popularity among scientists and was found useful in laboratory investigations. Investigatory approach is useful not only in understanding scientific phenomena but also in finding answers to social phenomena. The method is now increasingly used to teach science, social science and languages.

The investigatory approach involves stating the question to be investigated, formulating the hypothesis, suggesting the experiment, identifying the dependent and independent variables, conducting the experiment, recording the observations, analysing the data, generalising and drawing the conclusions.

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7

Creative Writing

7.1 Rationale

One of the major objectives of secondary school curriculum is to develop creativity among pupils. That is, the individuals must be creative in their approach to people, situations, problems and materials which help them to adjust effectively in school and democratic society. One of the effective methods of developing creativity is creative writing which allows creative self-expression. Creative expression helps students to satisfy their needs of security and communication, and developing self-confidence.

Creativity has been defined in different ways by different authors. Psychologists (Guilford, Torrance) believe that a creative product and process have the elements of originality, flexibility, elaboration, divergent thinking and usefulness. Some psychologists associate creativity with spontaneity and joyousness of imagination, ideas and emotions. The definition of creative act by Donald Berger may help teachers in understanding the functional concept of creativity.

> Creativity implies a fresh response, unique to the creator; it is characterised by personal initiative and conscious effort; it involves thinking and doing according to self-applied tests; and is finally judged as an accurate expression by the initiator.

This definition emphasises the novel synthesis of an individual's work. Teachers may find this definition useful to apply to their pupils' work. To develop creative expression among students, teachers use a variety of resource materials and methods. Creativity grows out of experiences and represents the unique reconstruction of something already existent so that a fresh, more useful product or idea emerges. To provide quality experiences and resource materials to students to develop strong

motivation for creativity and for fostering creative expression, teachers need to understand creativity. Creative writing is the most useful method for developing creative expression as writing can have all the elements of creativity.

7.1.1 *Objectives*

After reading this chapter, you will be able to:

(i) use creative writing as a transactional strategy;
(ii) understand the process of cognitive coding in creative writing;
(iii) identify steps to implement creative writing in teaching of curricular subjects; and
(iv) identify tasks of creative writing.

7.2 Psychological Basis - Cognitive Coding

In creative writing content or thought comes first and expression later. Creative writing strategy has been classified under 'Cognitive code methods of teaching a language'. Cognitive code method is helpful in developing the thought aspect of the language. It has two processes (i) reading and (ii) writing. Of four skills of language, namely, listening, speaking, reading and writing, the first two, that is, listening and speaking are learnt naturally from the environment whereas reading and writing are learnt as a result of formal teaching or training. Language is a tool with which we think and therefore our language influences our thought processes and thinking.

Bruner (1975) suggests that the constant use of language over and above the mere possession of it makes human beings 'profoundly different in mental powers; 'and more particularly does it matter that one writes and reads rather than talks and listens' because this moves language towards 'context free elaboration'.

The most dramatic step in this direction was the development of notional systems that rendered spoken language into graphic form. 'Linguistic competence' is the possession of the language system; 'Communicative competence' is its use in the large variety of social situations. Bruner offers us a third term, 'Analytic competence' the development of which is promoted by schooling and particularly by literacy. Its principal feature, as with Piaget's formal operations, is that it involves the prolonged operation of thought exclusively on linguistic representations, on prepositional

structures, accompanied by strategies of thought and direct experience with objects and events and with ensembles of propositions. It seems clear, what causes us to think is a higher cognitive level in thinking which we may describe as Proposition – For, Against and Conclusion.

Creative writing can be used to develop cognitive, affective and moral abilities among student. Some of the functions and activities that require creative writing ability are illustrated here:

Table 7.1

Functions	*Activity*	*Example*
Cognitive Reporting Planning Arguing Explaining Persuading Classifying	Selectivity Hypothesis and prediction Weighing evidence Entering mind of reader Sensing others' attitudes Organising in categories	Annual report Five-year plan Public enquiry-judgment Textbook Charity letter Flora
Affective Reflecting Empathising Setting Coping	Discovering self-awareness Entering the uniqueness of others Interacting with non-human phenomena Defining stance towards the human condition	Diary Novel Fable Poem
Moral Evaluating	Appraising experience in terms of a moral universe.	Parable

7.3 Creative Writing as a Transactional Strategy

Creative writing is a process that enables creative persons to discover ideas, make connections and see from new perspectives. In this sense, creative writing is a creative process of thinking and learning — about oneself, about others and about the world.

The teaching strategies are derived from psychological models of teaching. These can be 'content loaded' or 'content free'. The

strategies used to transact the prescribed curriculum to achieve the objectives of the curriculum are referred to as 'transactional strategies' and they are 'content loaded'. The effectiveness or the potentiality of this strategy for developing higher cognitive and affective abilities has been established by researchers.

7.4 Organizing Teaching – Learning Process

Although creative expression seems to be an innate need of high school students, it is not easy to teach. For effective creative writing one must combine the natural impulse to express feelings in words, an impulse most students already have, with considerable skill in manipulating words and images. Thus, the effective creative writing class is one in which a proper balance is struck between freedom and discipline — the freedom to play with ideas and express deep feelings, and the discipline of literary craftsmanship and adequate and appropriate vocabulary, syntax and language constructs.

7.5 Steps to Implement Creative Writing

(i) Allow students to express freely

Most of the students' previous school experiences have probably not encouraged them to express their personal ideas and feelings in a genuine way. One may need to place at the beginning of the year most of the emphasis on helping students feel comfortable to express their honest feelings. Spontaneous creativity flourishes primarily in an atmosphere of trust and acceptance. Since creative writing demands self-disclosure, students need to feel assured that they will not be exposing themselves to ridicule if others learn their inner thoughts. The role of the teacher is most important in creating the proper climate for growth in creative writing. The creative writing teacher functions as a sort of senior advisory group member who facilitates creative expression.

(ii) Allow students to assess themselves

The students will benefit from activities that encourage them to examine and talk about their own experiences and comparing their experiences with those of the other students and seeing their similarities. Comparative study of each individual's experiences with other students in the group will pave way for meeting similar incidents in future.

(iii) Offer good models of writing

Self-expression alone is not creative writing, no matter how genuine it may be. Therefore, in addition to encouraging students to write about the writer's craft, one of the best ways to teach is through models of good writing. Anyone who is skilled as a writer is also an enthusiastic reader. Reading serves not only as a stimulus to the writer's thoughts and imagination, but also as an introduction to a variety of styles, to the use of literacy devices and to the approaches a writer can take. Hence, the study of literature is a logical component of the total creative writing program. Identifying the choices made by other writers often motivates students to explore their own skill with various literary forms.

(iv) Teach principles and patterns

Principles and patterns are probably best taught inductively from literature rather than from a list of rules. The most effective way to teach a principle or pattern is to start with a work of literature that students themselves respond to, perhaps even the best of their own writing. Lead them to identify the device or pattern. Then give them the proper label for it. For example, students may feel the suspense in descriptive words, and the events that created that response. Once students have perceived a device or pattern and have learned the name for it, encourage them to continue to be alert for this device or pattern in other works they read and to try it out themselves in their writing.

(v) Provide students with appropriate feedback

Although it is important to respond to any of students' creative efforts if the goal is to help them improve their writing skills, one must provide them accurate feedback as well as encouragement. *Good feedback should be focused, specific, and constructive.* That is, it is limited to a few important aspects of the piece of writing that the student can improve with continued practice, and it identifies the writer's strengths as well as the weaknesses. A valuable source of feedback on a student's writing is the reactions of other members of the class. One way of providing feedback could be as described here.

- One student reads aloud his piece of creative writing.
- Other students analyse the ideas expressed in this piece of writing.

- If the author's message is different from what others perceive, then author explains his intentions and ideas.
- Other students provide constructive suggestions to improve the writing.
- If author's message is well understood by other students, then peers discuss whether the ideas provided are original and what kind of elaboration can make writing more interesting and meaningful etc.

7.6 Tasks of Creative Writing

Experiments on the development of cognition in writing suggested five tasks which could be used to develop creative writing ability among students.

Table 7.2
Tasks Requiring Creative Writing Ability

Reporting	Reporting an event
Instructing-	Telling how to do something
Suggesting	Giving one's point of view
Argument	For and against
Classifying	Organising information

Reporting

In connection with the school sports day, the children could be asked as 'outside' reporters to make notes and prepare a report in writing, which they could present on video. It could be suggested that the event should be introduced, described, and assessed. For example, a newspaper account of a school sports day could be shown to the children, read out and discussed. This type of training will encourage the students to become reporters, anchors and commentators in future life.

Instructing

Live demonstrations to be organised in the presence of students, say preparing tea/ice cream and from what they have seen, to write for someone who does not know the process but wishes to carry it out. The process should be familiar to all writers from such visual experiences.

Suggesting

The task could be something similar to asking the children to write a letter of suggestion. For example, the head of the corresponding secondary school felt it was no longer possible for school children to use the library on his premises. Needless to say, this is not an arbitrary decision as it appeared to the children, but in writing to him they felt they had a real case to suggest for convincing him.

Argument

The topic could be something like "Is playtime a good or a bad thing?" It could be discussed, suggested and a format can be offered. For example,

- Give a personal view on playtime.
- One paragraph for the 'good side' (for) and one paragraph for the 'bad side' (against)
- Summary and restatement

Classifying

The task chosen could be like, to ask the children to write the particulars of houses they live in, they have visited or have seen. It is suggested that they may present random information. In the discussion of the lesson, guidance about classification should be given on outside view of the house, entrance into drawing room, living rooms, internal ventilation etc.

Students should be encouraged to do these tasks in all the curricular areas. They may select themes from science and technology, social sciences or languages. Generating new ideas, organising and expressing these ideas should be tried out by students with a number of diverse themes from different curricular areas. Teachers can suggest a variety of activities which require students to write creatively.

Focus on Writing (Ontario Ministry of Education, 1982, p.6) suggests that works of synthesis and translation also require creative writing ability. Following writing activities may help students in developing the creative writing ability.

Table 7.3

Function	*Activity*	*Example*
Translation	Envisages information Envisages in a form Represented in a form other than the original	Describes an object; records an experiment; writes labels; records measurement; describes an event from the picture showing it, describes and interprets graphical information; writes captions; writes out an interview; describes an Indian village from its model.
Synthesis	Uses original thought to solve a problem	Writes poetry (haiku); designs and carries out an experiment; writes a story of a fictional event; writes in response to music or painting; rewrites an ending to story; writes what came before a story started.

7.7 Illustrations:

Example1

APJ Abdul Kalam from *Steps*
Textbook for Class IX (NCERT, 2002)

Method: Ask the children to collect newspaper cuttings on Abdul Kalam, specifically in terms of where he went.

Then ask them to prepare his itinerancy for one week.

This could be individual work or group work.

Ability to be developed: Critical thinking.
Creative writing.

Example 2

Students may be asked to write on a variety of themes such as:

- Describe flora and fauna in your surroundings.
- Write analytical views on 'education as a fundamental right'.

Example 3

Students may be asked to write descriptions from pictures, graphs and models.

- Picture of an event.
- A story in picture form.
- Graphical representations of trends.
- Model of a village on the top of a hill or by the sea shore.

7.8 Summary

Creative writing strategy is classified under Cognitive Code approach of teaching a language. The cognitive code approach is helpful in developing the thought aspect of the language. The guidelines in implementing creative writing are – students to freely express themselves, allow them to assess by themselves their own writings, offer good models of writing, teach principles and patterns and provide students appropriate feedback. The tasks of creative writing like reporting, instructing, suggesting, argument and classifying were suggested to be undertaken in a classroom.

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8

Social Inquiry Approach

8.1 Rationale

From constructivist point of view the objective of social inquiry is to understand the complex world of lived experience from the point of view of those who live it. The purpose of inquiry is not a matter of getting in touch with the ready-made world, rather remaking the world starting from worlds already on hand. Social constructivists assume that the terms by which world is understood are social artifacts, products of historically situated interchanges among people.

The act of inquiry begins with issues and/or concerns of participants and unfolds through a dialectic of iteration, analysis, critique, reiteration, reanalysis and so on that leads eventually to a joint (among inquirer and respondents) construction of knowledge. The joint constructions that emerge from the activity of enquiry can be evaluated for their 'fit', that is, whether these provide credible level of understanding or not and to what extent these have 'relevance' and are modifiable. This approach helps students in the construction of new knowledge. The methods that can be used for social inquiry include field survey and research.

8.1.1 Objectives

After reading this chapter, you will be able to

- understand the philosophical and psychological basis of social inquiry approach;
- organise teaching-learning using this approach;
- identify steps in field survey/research;
- understand the usefulness of this approach to develop higher order cognitive and affective abilities.

8.2 Philosophical and Psychological Basis

The social inquiry approach is based on the belief that the promotion of a reflective and inquiry frame of reference to the social issues and problems will improve the quality of personal and social existence. Massialas and Cox take the position that school is an active participant in shaping the culture and values of the society and call school the 'creative reconstruction of the culture'. They firmly believe that school cannot avoid the value controversies that are prevalent in the pluralistic society. Instead school must deal actively with the serious and critical areas of public controversy. Thelen, Oliner and Sharer also share these concerns.

Social inquiry is helpful in identifying the social issues and dealing effectively with these. The method of field survey and research is based on social enquiry approach. Massialas and Cox stress three main aspects of social enquiry. First of these is the open climate, second is hypothetical solutions and third is the use of facts as evidence. This philosophy emphasises research or evidence based construction of social reality.

Constructivists believe that knowledge and truth are created and not discovered by mind. They emphasise the pluralistic and plastic character of reality. Pluralistic means that reality is expressible in a variety of symbols and language systems. Plastic means that reality can be shaped to fit purposeful intentions of human agents. We invent concepts, models and schemes to make sense of experience and continually test and modify these constructions in the light of new experience.

According to Vygotsky, learner constructs knowledge in the cultural and social context in which the learner is embedded. Learning involves interaction with peers, teachers and social groups in the community. During the interactive process, meanings are shared, and information is exchanged. The values and culture of the society influence learners' thinking. Social interaction encourages students to compare their ideas with those of others. Students develop thinking skills by interaction with others. In social inquiry approach students can learn from community and also experts working in the field. Students construct knowledge from social realities.

8.3 Organising Teaching and Learning

Teaching models of social family suggest various methods of

organising teaching-learning using social enquiry approach. This approach is useful for investigating into the social problems and issues and evolving solutions to these. The social family model basically focuses on the human group and represents ways of teaching that emphasises group energy, interpersonal skills and social commitment. Intrinsic to this method is the fact that learners actively seek out rather than receive knowledge through lectures, demonstrations or reading textbooks and so on.

Herbert Thelen's group investigation model attempts to combine the programme and dynamics of the democratic process with the process of academic inquiry. Thelen suggests an experience based learning situation easily transferable to later life situations and characterised by a vigorous level of enquiry. The concepts of inquiry, knowledge and dynamics of group learning are central in this strategy. Inquiry into the real situations and ongoing experiences continually generates new data. Development of knowledge is the goal of inquiry. Knowledge of group dynamics is necessary for using group investigation approach. Thelen feels that a 'teachable group' is a pre-requisite for a productive group investigation. There should be enough commonality of values that will facilitate communication and working but there should be enough difference to generate alternative relations. The teaching-learning can be organised in following six phases.

Phase I : Encounters conflicting or puzzling situation

↓

Phase II : Explores reactions to the situation

↓

Phase III : Formulate hypothesis, plan and organise activities (data gathering)

↓

Phase IV : Independent and group study

↓

Phase V : Analysing the process and data

↓

Phase VI : Drawing feedback and recycle activity

The second model of social enquiry known as *jurisprudential inquiry* was suggested by Donal Oliver and James P.Shaver. The basic emphasis in this model is to help the students learn to

think systematically about the extemporary issues. This model is especially useful in helping people rethink their position on important legal, ethical and social issues. By giving learners tools for analysing and debating social issues, the jurisprudential approach helps students participate forcefully in the redefinition of social values. This helps students in clarifying and resolving issues. Another competency that can be developed in this model is the knowledge of contemporary political and public issues which in turn require that students be exposed to the spectrum of political, social and economic problems facing the society. This model is generally used for case studies. It involves six phases:

Phase I	:	Orientation to the case
		↓
Phase II	:	Identifying the issues
		↓
Phase III	:	Taking positions
		↓
Phase IV	:	Exploring the stances underlying the position taken
		↓
Phase V	:	Redefining and qualifying positions
		↓
Phase VI	:	Testing assumptions about facts, consequences and definitions

The six phases of this model can be broadly divided into analysis (Phases I to III) and argumentation (Phase IV to VI). The role of teacher in these phases is that of a guide and facilitator. In Phase I, the teacher will introduce students to the case by reading aloud a story, narrating a historical event, showing a film depicting a value controversy or discussing an incident from the lives of students or the community. Students review and analyse the event or case by outlining who did what and why and under what circumstances.

In Phase II the students synthesise the facts into a policy issue and characterise the values involved such as freedom of speech, school autonomy, or issue of equal opportunities and identify conflicting views or values.

In Phase III, students articulate their position on the issue or value and state the basis for their position. In Phase IV, their

positions are explored and argued. The teacher shifts to confronter style as she probes the students' positions. In Phase V, students refine their positions. This phase often naturally flows from the dialogue in Phase IV but sometimes the teacher may need to prompt students to restate their positions. While Phase V clarifies and reasons the value positions taken by students, Phase VI further tests the positions by identifying the factual assumptions behind it after examining these carefully.

Another model for social inquiry is proposed by Byron Massialas and Benjamin Cox. The emphasis in this model is on developing students' capacity to inquiry and to reflect on the nature of social life, particularly with the course of their own lives and directions of the society. Phases for carrying out inquiry in the social studies are:

Phase I	Orientation
	↓
Phase II	Hypothesis
	↓
Phase III	Exploration
	↓
Phase IV	Evidencing
	↓
Phase V	Generalisation

Orientation is simply the sensitisation of the teachers and students to a problem in the social domain. The starting point can be a question that calls for an explanatory relationship, solution or policy. The second stage of inquiry is the development of a hypothesis. The hypothesis serves as a guide to inquiry. During exploration, the hypothesis is extended in terms of its implications and assumptions and then deductions can be made from it. During the 'evidencing', facts and evidence needed to support the hypothesis are gathered in terms of conditions that have been hypothesised and defined. The 'generalisation' involves the expressions of solution of the problem. During all the stages/ phases, the teacher is a counselor to enquiry, helping students clarify their position, improve the process of study and work out their plans.

Inquiry calls for first hand activity in a real situation and ongoing experiences that continually generate new data. The goal of inquiry is the development of knowledge. Inquiry can be

conducted in groups. Ideally, about ten to fifteen students should comprise the investigating group. This number is large enough for diversity of reactions and small enough for individual participation.

There are certain common characteristics that you have to keep in mind while constituting the investigating groups. There should be enough commonality of values so that communication is easy and ways of working are similar, but at the same time there should be enough differences to generate alternative reactions. The group members should possess a common level of sophistication and orientation towards the knowledge to be investigated.

Thellen feels that a "teachable group" is a pre-requisite of any productive group investigation. Each inquiry starts with a stimulus situation to which students can react and discover basic conflicts among their attitudes, ideas and modes of perception.

8.4 Conducting Small Research Projects /Surveys

In this approach teachers guide students in conducting small research projects/ surveys based on evidence from the field. Whether students decide to take a qualitative or quantitative approach depends on the nature of the topic and purpose of research. In qualitative research, relatively large amount of depth information is obtained from a small number of individuals or settings, whereas in quantitative research relatively less information is obtained from a large number of respondents. The approaches are not necessarily mutually exclusive; both could be employed to investigate a research problem.

Qualitative research asks what the characteristics of a social behaviour or setting are, what forms they assume and the variations they display (Lofland, 1971). The methodologies used in qualitative research include case studies, depth interviewing, focused group discussions, ethnography, participant observation and content analysis of documents. Qualitative research methods are useful for providing a descriptive background and understanding of the human relationships.

Quantitative research aims at describing groups of individuals or settings in ways that can be counted. Quantitative analysis assumes relationships between variables. The data can be collected without assuming relationship between variables but such a data would be descriptive and not analytical. For example, the failure rate in board examinations. But to find out the causes

and consequences of this failure rate, the researcher needs to identify the dependent and independent variables and the relationships between these. Field survey is a type of quantitative research. This is a systematic approach to data collection and analysis; survey research emphasises scope rather than depth. For surveys structured questionnaires are used.

8.4.1 Steps in conducting field surveys and research

(I) Identifying the area/topic of research

The first step in using field research/survey as a transactional strategy is to help students in identifying the areas where field research can be used for new learning. This step involves meetings, consultations and seminars with students, other teachers and persons with experience in the area of interest. For participating in such meetings and seminars, students require knowledge of prior studies in the area of interest and conceptual framework out of which the research question arises.

(II) To identify the research questions/problem

The second step is to identify the research questions or problem to be investigated. For identifying the research questions, students require good knowledge of the subject matter. The problem to be investigated should be clearly and explicitly stated. The problem statement or research questions should cover the major issues to be investigated, including operational definition of terms and concepts used. This may also include the hypothesis to be tested.

(III) Selecting the sample

For selecting the sample, first define the theoretical population — what persons, documents or other sources will be used in this study. The most common method for selecting a probability sample is the simple random sample. A simple random sample is like the lottery procedure: all names are written on slips of paper and placed in a large container and then required number of slips are taken out of the container one by one. Selecting sample using simple random sample requires more time and costs in listing all the cases in the population and selecting cases at random.

To reduce cost and time other types of sampling techniques can also be employed. These include systematic sampling and

stratified sampling. In systematic sampling every tenth case after a random start might be selected so that a sample of 100 is chosen from a population of 1000. In stratified sampling, sample is drawn from two subsets of the population. For example drawing separate samples of boys and girls from a student population.

These methods of sampling can be used for both qualitative and quantitative research. For example, for observing the classroom interactions in a school, the researcher would like to knows what types of classes were held and how often. We would not like to generalise about all classroom interactions if our observations were made primarily during work experience or sports class.

(IV) Collecting the data

Collecting of data has two phases, first is the development of tools and second is the field work or field visit to collect the data. (a) *Tools and techniques* for data collection can be questionnaires, observation schedules, structural or non structural interview schedules, inventories, field notes etc. Of these, social scientists generally use the techniques of depth interviewing and participant-observation, involving the assembling of field notes. These techniques attempt to describe the range and variability of a social phenomenon.

While preparing the field notes, first determine the particular aspects you want to study, prepare field notes in the chronological log of your observations. One purpose of recording your observations is to keep a record of changes in behavior, changes in your understanding of situations.

While using interview technique, organise your interview questions around cluster of ideas or variable about which you wish to collect information, construct an interview schedule according to the nature of topic for discussion. The schedule should consist of a small number of neutral questions that will lead your respondents to tell about your topic. It will be helpful to arrange your interview schedule in terms of two columns, with the general suggestions for open statements and questions on the left and suggestions for follow-ups on the right.

Communicate at the level of the respondent. The emphasis should be placed upon obtaining information in the respondents, own terms. The aim is to provide a list of things to ask about when talking to the respondent and not to develop a rigid set of questions.

Questionnaires are generally used for quantitative (survey) research. In designing a structured questionnaire there are a number of options for generating an item pool of individual questions. In formulating the questions it is important to use language on the respondent's level. Avoid long questions, which might be ambiguous or confusing. Limit questions to a single idea or reference. You also have to decide whether questions will be open-ended, asking the respondent to supply answer or closed-ended, asking the respondent to choose an answer from a list provided. Closed-ended questions provide greater uniformity of answer and are more quickly processed. If closed-ended questions are provided, then care must be taken to ensure that the response categories are mutually exclusive and exhaustive, that is, each respondent can select one and only one response category. The disadvantage of closed–ended questions is that the structuring of the responses may overlook some important dimensions. Open-ended questions are useful for establishing the range of possible answers when these cannot be estimated in advance.

The format of the questionnaire is just as important as the nature and working of the questions. Boxes, parentheses or code number should be placed besides the response categories to facilitate coding. Placement of questions in the questionnaires is also important. Group related question should be put together. The initial questions should be interesting and unthreatening. The sensitive and dull questions should come last. Provide general instructions for filling-up the questionnaires in the beginning. The questionnaires can be pre-tested on a small sample.

(b) Field visits

The second part, field visits, discusses the role of teacher in taking students for data collection. Field visits must be undertaken in groups with the teacher as the guide and leader of the group. For this, teachers need to pre-plan and obtain permission from school and the organisation/community to be visited. Teacher has to arrange for transport and other logistics also. Teachers can prepare a planning sheet for field visits including following items.

(i) Objectives of the field visit.

(ii) Place to be visited.

(iii) Class, names of students, their role numbers.
(iv) Expenditure on visit and its sanction from the concerned authority.
(v) Approval from the Principal of school.
(vi) Approval from parents of students.
(vii) Permission from the organisation/community to be visited.

On the day of visit, teacher must take attendance of the students going on field visit. On the fieldwork teacher must have connectivity with all the students. As a guide teacher must help students in overcoming the difficulties during fieldwork

(V) Processing the data

Data collected by the members of the group is subjected to analysis and scrutiny of the group. For quantitative research, simple statistical techniques can also be used. On the basis of analysis of the data and in-depth discussion on collected information, the students will be able to evolve a holistic view about the problem investigated by them.

(VI) Preparation and presentation of report

For presentation, the study must be placed in its general scientific context, giving the relevant findings and their implications. The report should contain an introduction, a description of the research procedures, a summary of the results and a discussion of the implications of the study for further research.

In the introduction, enough background information should be provided clarifying and justifying the worthiness of the investigation. It may also include how the problem is related to previous research, general theoretical models and refer to the identification and solution of some social issues. The research questions or research problem should be clearly stated. The hypotheses of the study should be stated. Definitions of major concepts and terms used should also be given.

In describing the method, research procedures including sampling, tools and method of data collection should be given. Identify who the respondents were, how they were selected and how many responded and are included in the study. Describe how these observations are related to the variables under study. Also describe the administration of tools, your own field experiences related to the study etc. The most important part of research report is the findings and their interpretation. The results may be supported by tables and graphs. State your

conclusions on the basis of these. Discussion of the implications of the study for further research should also be given.

8.5 Illustration from Curricular Subjects

The illustrations given in this section illustrate that social inquiry approach can be used to teach different curricular subjects and to develop abilities of analytical thinking, attitudes and values.

8.5.1 Social Studies

Example 1

Topic - Status of Indian Women (Civics Component)

Objectives

- to develop awareness about the position of Indian women.
- to develop healthy attitude towards women
- to objectively analyse issue related to status of women.

Procedure – Prepare a questionnaire consisting of 25 questions. Select a sample of about 30 families belonging to rural and urban strata of the society. Draw sample from three different income groups - higher, middle and lower. Then administer the questionnaire to women members in these families. The questionnaire may contain questions on the following indicators:

- Marital status.
- If married, number of children.
- Educational status.
- Employment status.
- Nature of work done at office.
- Number of working hours at work place.
- Time taken to commute to the office.
- Mode of travel.
- Work done at home.
- Any help available for doing household work.
- Economic freedom.
- Health status.

All the data must be collected and arranged group-wise. on the basis of these data the report has to be finalized by the respective students. Now the student work gives his/her conclusion about the position of Indian women from the random samples collected.

Example 2

- Turko Indian Art Under the Sultanati

Objectives

- to understand the Indo Islamic or Turko Indian art and its features.
- to appreciate India's cultural heritage.
- to develop analytical, reflective and creative thinking.

Procedure: Make an individual or group project on the Turko Indian Art. The project may concentrate on the following points.

(a) Collection of illustrations of monuments of Turko Indian Art.
(b) If possible visit (as many as possible) sites of Turko Indian Art.
(c) Identify the new styles introduced in their architecture and buildings (such as arch, minar, dome, baoli etc.)
(d) Identify the extent of synthesis between the Indian and Islamic architecture.
(e) Classify the materials used - how are these related to geographic and economic factors.
(f) Find out how Muslim and Hindu artisans worked together to produce excellent works of architecture and art.
(g) Identify the impact of synthesis of the two cultures on Indian society.

Teacher may organise visit to some important sites. Students search material from books in the school library. Students must submit the project report to the teacher along with the bibliography of books that he/she had read. The project should be properly presented. Evaluation of the project report would be done by the teacher keeping in view the level of students, considering clarity of facts, analysis and presentation of the report.

8.5.2 *English*

Example 3

Reading passage on Louis Braille or Ved Mehta or Poem by Milton 'On his Blindness'

Method: Field survey

- Take the children to the local blind school.
- The children should have prepared a questionnaire earlier where they can ask the followings questions to 10 people (you could add more questions).

		Agree	*Agree some what*	*Disagree*
1.	The education imparted to you is as good as that offered in the general school.			
2.	After you leave school, you will get equal opportunities for jobs as the other children			
3.	People treat you as well as they treat other children.			

- The children can make a pie-chart on the basis of this information.
- They then describe the pie-chart in writing.

Abilities to be developed: Analytical thinking, positive attitude and values

Language Skills: Writing, translation (transference of speaking information to non-verbal).

8.6 Summary

The philosophical belief underlying social inquiry approach is that a reflective and inquiry frame of reference will improve the quality of personal and social existence. Psychological theories state that a person learns to think by thinking and knowledge gained through self invention/creation is more meaningful, permanent and transferable than knowledge acquired from teachers using expository methods. Intrinsic to this method of teaching-learning is the assumption that students should actively seek knowledge through observations rather than receiving knowledge through lectures, demonstrations, textbook reading or recitation. The teaching-learning requires a student to draw conclusions, construct concepts from generalisations through observation, induction and deduction. To use this approach effectively, proper planning and good prior knowledge of the subject area is required.

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NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

ISBN 81-7450-475-3